Edition 2021

Ship&Offshore

Special **GreenTech**

- Sustainable Global Shipping
- Future Fuels
- Propulsion & Engine Technology
- Retrofit & Conversion
- Emission Control
- Surface Technology
- Waste & Water Treatment
- The Green Port

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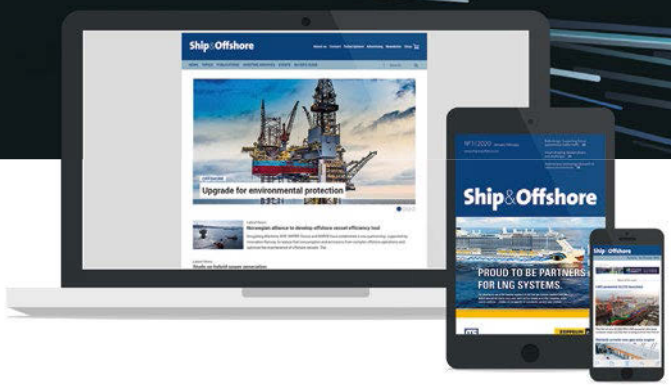

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Nice to have, but not enough

The ambitions of the international shipping industry to reduce CO_2 emissions and thus achieve the IMO's climate targets remain unbroken. By adopting the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CCI) at its recent session, the IMO's Marine Environment Protection Committee (MEPC) agreed to important short-term measures to mitigate greenhouse gas emissions in shipping.

It is now a question of filling those measures with life and helping shipowners calculate the index and assess the various options for compliance strategies. What's more, some suggest that it may be necessary to discuss if and what kind of sanctions there will be for those failing to comply.

As always with new regulations, some welcome them, for others they don't go far enough, and then there are sceptics who doubt their efficacy and see too many hurdles in complying with them.

In any case, it is to be welcomed that IMO member states were able to agree at relatively short notice on the next steps on the road to climate-neutral shipping. However, at this point, the conditions only apply until 2026; a specific clause requires the IMO to review the effectiveness of the implementation of the CII and EEXI requirements by January 1st 2026 at the latest, and, if necessary, develop and adopt further amendments.

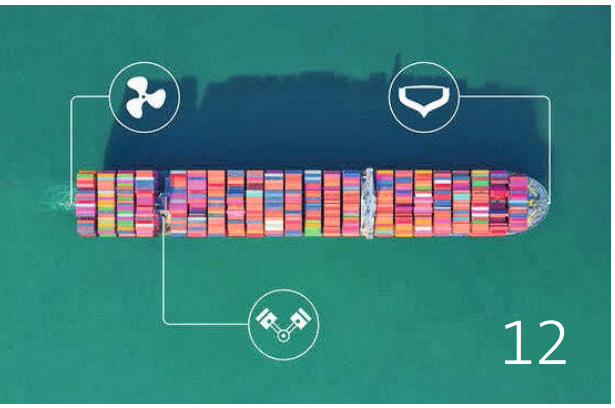
Given the relatively long lives of ships, that is virtually the day after tomorrow and severely restricts the ability of shipowners to plan ahead reasonably. Anyone who orders new ships today – which, unlike the fleet in service, are subject to the EEDI introduced in 2013 – must be sure that their ships can also continue to operate effectively despite the tighter regulatory regime that is likely over the next 20 years.

But, let's face it, that's not possible. To establish a climate-neutral or emissions-free shipping industry, it is first and foremost necessary to have the appropriate fuels. And at the moment, whilst there are plenty of good ideas, these are either still under development, not yet available at competitive prices, and lack a robust global supply infrastructure.

One significant disappointment following the outcomes of MEPC 76 was the absence of proposals on funding the vast R&D programme that will be required for the development of new zero-carbon and carbon-free fuels. Already in 2019, industry associations, including BIMCO, the International Chamber of Shipping and CLIA, put forward the idea of setting up an International Maritime Research and Development Board (IMRB), which is funded by shipowners over a period of ten years. Two years later, a decision on this proposal remains on hold.

The maritime industry has proven time and again that it is innovative, that it can respond to change and that it can successfully advance forward-looking technologies. But alas, the pace of progress that is required needs a dependable and mandatory regulatory framework and, of course, development money to push forward what is needed for a green industry.

Ideas and opportunities are there – and this year, too, the readers of our GreenTech Special Edition can convince themselves of this.



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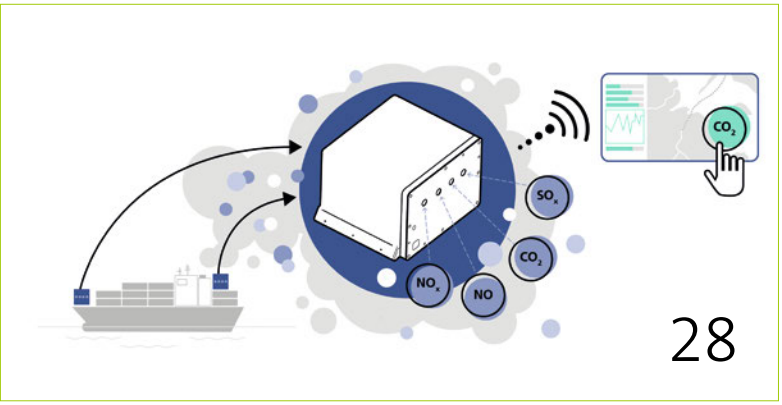

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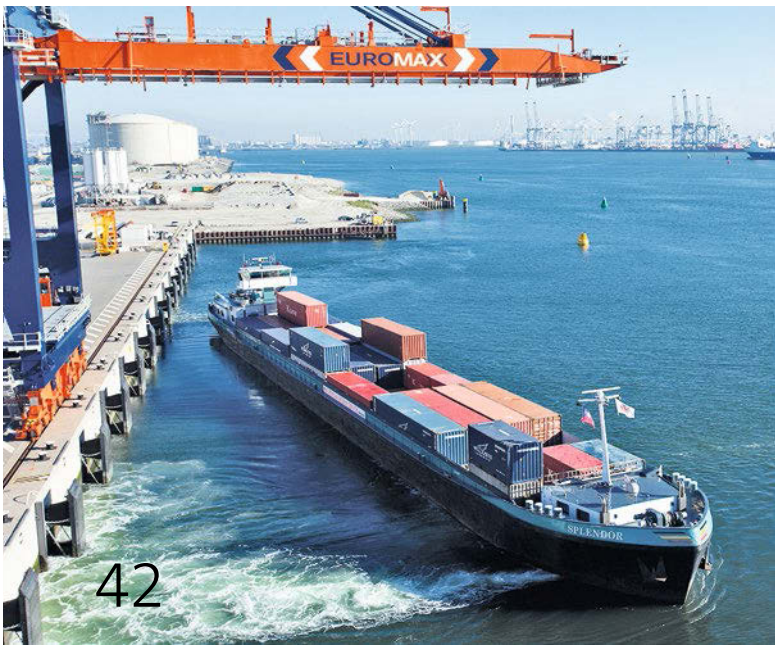

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Further shipping GHG emission

MEPC 76 New mandatory measures to cut the carbon intensity of international shipping have been adopted by the International Maritime Organization (IMO), setting shipping on a course to meet greenhouse gas (GHG) reduction targets established in the 2018 Initial IMO Strategy for Reducing GHG Emissions from Ships

IMO's Marine Environment Protection Committee (MEPC 76), meeting in a remote session from June 10th to 17th 2021, adopted amendments to the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI that will require ships to reduce their greenhouse gas emissions. These amendments combine technical and operational approaches to improve the energy efficiency of ships, also providing important building blocks for future GHG reduction measures.

The new measures will require all ships to calculate their Energy Efficiency Existing Ship Index (EEXI), following technical means to improve their energy efficiency, and to establish their annual operational Carbon Intensity Indicator (CII) and CII rating. Carbon intensity links the GHG emissions to the amount of cargo carried and distance travelled.

Ships will be assigned a rating of their energy efficiency (A, B, C, D, E – where A is the best). Administrations, port authorities and other stakeholders as appropriate, are encouraged to provide incentives to ships rated A or B, while also sending out a strong signal to the market and financial sector.

A ship rated D for three consecutive years, or E, is required to submit a corrective action plan, to show how the required index (C or above) would be achieved.

IMO Secretary-General Kitack Lim said the adoption of the new measures would build on IMO's previously adopted mandatory energy efficiency measures, to lead shipping on the right path towards decarbonisation.

"The path to decarbonisation is a long, but also a common path in which we need to consider and respect each other's views. We have made a considerable amount of progress since the start of our journey," Lim said.

The amendments to MARPOL Annex VI (adopted in a consolidated revised Annex VI) are expected to enter into force on November 1st 2022, with the requirements for EEXI and CII certification coming into effect from January 1st 2023. This means that the first annual reporting will be completed in 2023, with the first rating given in 2024.

A review clause requires the IMO to assess the effectiveness of the implementation of the CII and EEXI requirements, by January 1st 2026 at the latest, and, if necessary, develop and adopt further amendments.

Meeting the initial GHG strategy ambition

The combined technical and operational measures, referred to as short term carbon intensity measures, are in line with the

reduction measures adopted

ambition of the Initial IMO GHG Strategy, which aims to reduce carbon intensity of international shipping by 40% by 2030, compared with 2008.

The initial strategy sets out short-, mid-, and long-term measures. The measures just adopted fall into the short-term measures.

Future work

The MEPC also discussed a number of submissions on how to progress the next stages of IMO's work to cut GHG emissions from ships, leading to the revision of the initial GHG strategy in 2023.

The MEPC adopted a work plan on the concrete way forward to make progress with candidate mid- and long-term measures including steps to incentivise the move away from fossil fuels to low- and zero-carbon fuels to achieve decarbonisation of international shipping.

A proposal initially considered by MEPC suggested a mandatory levy of USD 100 per tonne carbon dioxide equivalent on heavy fuel oil. This proposal will be further considered at the intersessional working group meeting in the context of the adopted workplan together with other proposals for mid-term measures.

Prohibiting HFO in the Arctic

The MEPC also adopted amendments to MARPOL Annex I (addition of a new regulation 43A) to introduce a prohibition on the use and carriage for use as fuel of heavy fuel oil (HFO) by ships in Arctic waters on and after July 1st 2024.

The prohibition will cover the use and carriage for use as fuel of oils having a density at 15°C higher than 900 kg/m^3 or a kinematic viscosity at 50°C higher than 180mm^2/s. Ships engaged in securing the safety of ships, or in search and rescue operations, and ships dedicated to oil spill preparedness and response would be exempted. Ships which meet certain construction standards with regard to oil fuel tank protection would need to comply on and after July 1st 2029.

A Party to MARPOL with a coastline bordering Arctic waters may temporarily waive the requirements for ships flying its flag while operating in waters subject to that Party's sovereignty or jurisdiction, up to July 1st 2029.

New efficiency standard for existing fleet

EEXI From January 2023, most commercial vessels will have to comply with the new Energy Efficiency Existing Ship Index (EEXI) standard. The EEXI introduces the same energy efficiency requirements for existing ships as those that were put in place for newbuildings by the EEDI in 2013. To comply with the standard, owners, classification societies and equipment suppliers must all take action now. Ship&Offshore spoke with Andy McKeran, Maritime Performance Services Director at Lloyd's Register about the implementation of the EEXI. We also asked two propulsion experts, Christoph Rofka, senior vice president – head of Global Product Group Medium, Low-Speed and Rail at ABB Turbocharging and German Weisser, WinGD R&D Senior Advisor, Sustainability, about measures that could be taken to comply with the regulation.

Andy, can you briefly summarise what the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Index (CII) mean for shipowners and their fleets?

Andy: It is really simple, EEXI requires existing ships to basically play a technical efficiency catch up with equivalent new EEDI (Energy Efficiency Design Index) compliant ships. Subsequently, compliance will mean whether a ship can continue to trade. Depending on the survey cycle of a ship, the compliance deadline could already be less than 18 months away.

For shipowners with pre-EEDI and early EEDI certified tonnage, EEXI could mean a significant amount of work, but we envisage for the majority, EEXI will not have a significant impact on the operation of their vessels. Our expectation is that the operational Carbon Intensity Index (CII) will apply to most of the global fleet above 5,000gt and is the main mechanism for delivering IMO 2030. This means that ships will need to adapt technically and operationally to meet specified annual carbon intensity reduction targets from 2023 and being rated based on their performance, and for most ship types will be measured on the Annual Efficiency Ratio (AER) and will be provided with a rating of A to E, depending on where they sit against the global benchmark.

During the recent International Maritime Organization (IMO) intersessional working group, we saw compromise built around an 11% reduction in AER at fleet level relative to 2019, with the door open to push further between 2026 and 2030. However, we believe that there will be a growing expectation that the IMO could pile on the pressure by raising the bar between 2026 and 2030, at the same time as the enforcement regime transitions move from "light touch" to materially penalising under-performance. At this stage, it is difficult to assess the impact, but intuitively the drive to push adaptation will impose a new constraint on commercial operations across the industry.

»There will be a mix of fuels in the market to meet different shipowners' needs and operations«

Andy McKeran, Maritime Performance Services Director at Lloyd's Register

Source: Lloyd's Register

What would you consider the best measures to comply with the new standards?

Andy: The right compliance strategies will be ship type and service specific. At Lloyd's Register, we are assisting shipowners and managers around the world with assessing their risk exposure and developing compliance strategies.

The timeframes involved and the influence of Covid-19 have certainly limited the potential to use invasive energy saving technologies to comply with EEXI in the first instance. In addition, the default Overridable Power Limitation (OPL) will only take a ship so far when viewed from the perspective of the future operational carbon intensity measures.

We expect owners to look at alternative solutions to OPLs after initially demonstrating compliance with EEXI. This will be driven by the need to adapt technically and operationally to avoid persistent underperformance against operational carbon intensity targets between 2023 and 2030, and the expectation that the IMO will strengthen the implementation and enforcement regime around operational carbon intensity from 2026.

That said, the landscape is complicated by the lack of clarity on the IMO approach to lifecycle GHG assessment of marine fuels, and the intentions for mid- and long-term measures to address the missing market for zero-carbon fuels.

Do you think that the EEXI is a suitable means on the way to achieving the climate goals in the maritime industry?

Andy: EEXI will not achieve IMO 2030 on its own, and it was never intended to; it locks in what the market has already delivered through slow steaming since 2008 and will leave other measures to do the heavy lifting.

Timing is tight for owners to comply. What steps do you recommend to owners and operators to meet the required thresholds in time?

Andy: My advice is to start preparing now to determine and manage compliance risk of both EEXI and operational carbon intensity, this way owners and operators can avoid unexpected disruption to ship operations. Without early preparation, this disruption could start as early as January 1st 2023.

While the EEXI is regarded as a short-time measure to reduce shipping's burden on the environment, the long-term goal is of course a renunciation of fossil fuels. Which of the currently discussed options (ammonia, hydrogen, fuel cells, etc.) do you consider most suitable and commercially viable?

Andy: This is not something anyone can answer right now. There will be a mix of fuels in the market to meet different shipowners needs/operations.

What is clear is that for the main options of ammonia, methanol and synthetic fuels, that hydrogen is the feedstock to all these fuels, thus hydrogen capability will be required.

Uncertainty can be managed by understanding the key drivers for different transition pathways including technology, economic and community readiness levels.

Hybridisation and diversification of the solutions may be used to manage the uncertainty, especially at the beginning of the transition before the fuel market may consolidate with a dominant solution.

Each pathway to zero is likely to involve several transitions or steps, and potentially multiple types of fuel. Investors and shipowners will make decisions based on their own circumstances and choose the appropriate pathway for their situation.

What do you think is needed in addition to the current standards to enable sustainable green shipping?

Andy: Policy and regulation which addresses the fundamental challenge facing shipping: a missing market for ultra-low and zero lifecycle GHG emissions fuels. The industry needs bold policy and regulation which builds market expectation that shipping will offer sustainable economic activity that is worth investing in. This will remove uncertainty and allow the necessary capital to flow into the industry. Without this, it is difficult to see how an energy transition in shipping can happen. ›


Source: ABB Turbocharging

»An important operational aspect will be monitoring engines to ensure they are working at optimal efficiency«

Christoph Rofka, Senior Vice President – Head of Global Product Group Medium, Low-Speed and Rail, ABB Turbocharging

Christoph and German, what is your opinion on the effectiveness of the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Index (CII)?

Christoph: The EEXI focuses on the design of vessels and can only be the starting point for reducing actual greenhouse gas emissions from vessels. Pending further development of the index at MEPC 76, it is expected that many current vessel designs will be able to meet the requirements by restricting engine power, a relatively straightforward procedure with many options to suit different vessels. For many operators, for example those already slow steaming, this will have hardly any impact on real emissions during operations. Nonetheless, EEXI will provide a necessary reference point and a base from which to build operational efficiency improvements.

The Carbon Intensity Index, which focuses on operational improvements, will have a greater impact. Again pending final details, this is likely to trigger operational optimisation by most ship operators and owners – for example finding optimal speeds, loadings, and hull cleaning and maintenance procedures to improve efficiency. Hardware upgrades will also help improve performance over time.

The IMO wants to ensure that there is continuous optimisation and improvement for all vessels. It is a good move, but it is focused on the short-term target of reducing shipping's carbon intensity by 40% by 2030. It does not bring any clarity on how to achieve the tougher 2050 target of reducing greenhouse gas emission by half and phasing them out completely thereafter. This aspect needs a strong focus from the IMO after MEPC 76, and quickly – the industry needs time to stimulate investments and build up the appropriate technologies and supply chains.

German: The EEXI is an important building block of the IMO's implementation plan of their Initial Strategy on GHG reduction in that it creates a level playfield between new and existing vessels. Moreover, the strengthening of the SEEMP by introducing the CII concept shifts the attention from technical or design measures to operational aspects. This reflects the fact that developments such as the adoption of alternative fuels cannot be properly represented in a design-based instrument such as the EEDI or EEXI.

What is your company's technological approach to support owners and operator in meeting the upcoming thresholds of CO_2 emissions?

German: WinGD is working on a large variety of technology developments, which are supporting the decarbonisation of shipping. Switching to LNG has been an important step in the right direction, but achieving the final targets requires tapping into all possible sources. This starts from the further optimisation of propulsion engines and all other equipment on board as well as overall vessel and hull design in particular. It includes the advanced integration of the energy systems on board and the utilisation of the potential of hybridisation on individual ships up to contributions to actual smart shipping concepts.

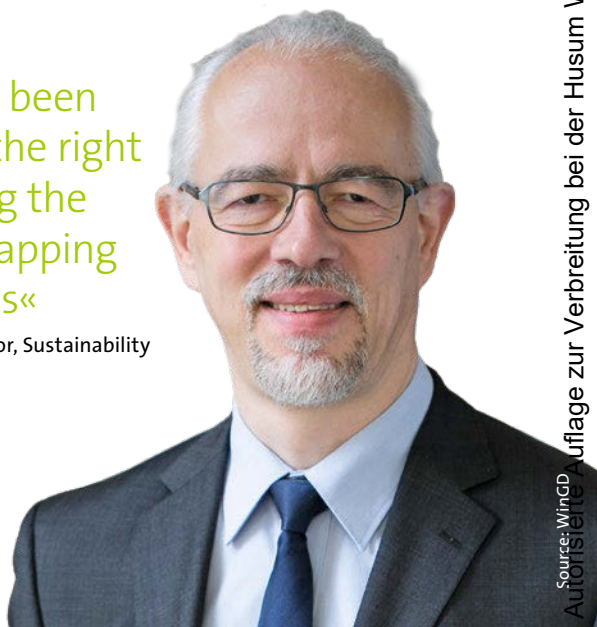
However, shipping will fall short of the 2050 targets without the early and massive adoption of what we call "X-Fuels". These X-Fuels include all variants of net carbon-neutral fuels, which can be either sustainably produced biofuels of second or higher generation, or synthetic fuels produced in a climate-neutral manner using excess renewable energy, as well as appropriate feedstock. The development of technologies for enabling the use of such X-Fuels on large two-stroke engines is an essential part of WinGD's development roadmap.

Christoph: The central role of turbochargers will remain the same – to help engines deliver the most efficient combustion from the smallest package. We will continue to develop products that advance turbocharger efficiency and, in many cases, there are simple upgrades and exchanges that can be made to ensure your turbochargers provide the best performance support for their engines across the vessel lifecycle.

Looking more specifically at EEXI and CII, we will support shipowners and operators by helping to deliver the engine and turbocharger adaptations needed to meet these requirements. 'Engine power limitation' is a broad term and there are many options – permanent engine de-rating, waste-gate installations or rematching turbochargers, for example. We have the engineering expertise to advise and execute the right options for our customers.

»Switching to LNG has been an important step in the right direction, but achieving the final targets requires tapping into all possible sources«

German Weisser, WinGD R&D Senior Advisor, Sustainability


Source: WinGD

Autorisierte Auflage zur Verbreitung bei der Husum Wind 2021

An important operational aspect will be monitoring engines to ensure they are working at optimal efficiency. Our Tekomar XPERT diagnostic and advisory platform will ensure that engines help vessels achieve the best possible CII each year. There is some discussion about whether CII will be applied on a vessel or fleet level. This software covers both. It accurately evaluates performance of individual engines, quantifying deviations and identifying potential fuel savings. The fleet version offers further efficiencies by benchmarking engine health your vessels, allowing operators to see further optimisation potential.

Looking further ahead, zero or net-zero carbon fuels will be needed to meet the IMO's 2050 ambition. There is notable uncertainty over which fuels and engine technologies will be used by shipping in the long-term. We have invested heavily in understanding these fuels and their implications for combustion concepts and engine technologies. We are confident, firstly, that engines will continue to drive much of shipping well beyond 2050 and, secondly, that ABB Turbocharging is ready to provide technology for engines operating on (net) carbon-neutral fuels.

In addition to those standards, what do you think is needed to enable sustainable green shipping?

Christoph: Shipping needs net-zero carbon fuels and there is no doubt any more that these will be based on hydrogen – green (from renewable energy) or blue (from fossil sources but using carbon capture). The biggest obstacles right now are the sluggish uptake of these fuels and the lack of major investment in their production. Investment in production needs to speed up as it is limiting availability and deterring investments in engine technology and shipping.

I think the industry should allow – and even push for – at least an intermediate stage that accepts blue hydrogen. This approach would allow shipping access to such fuels much faster. Because of the uptake of renewables globally, there are so many other industries that can make better use of these energy sources and shipping would have to wait too long even to come close to the IMO ambition.

There is lobbying and discussions with majors going on in this direction. The shipping industry must be vocal that hydrogen-based fuels with a net-zero carbon footprint are the aim, but in an intermediate phase we can accept fossil-based with carbon capture and storage. With this approach, we can at least get things moving.

German: Various boundary conditions need to be put in place for the adoption of X-Fuels. Considerable investments into their sustainable production are required, starting from the further development of production technologies. These need to be scaled up rapidly to relevant sizes, accompanied by the establishment of storage, distribution, and bunkering facilities. Ultimately, such fuels need to become available in sufficiently large quantities and at competitive prices. The latter will almost inevitably require political action for bridging the expected price gap between traditional fossil fuels and these X-Fuels. Moreover, the regulatory framework has to be enhanced for allowing the safe and reliable utilisation of such fuels in a marine environment.

These interviews were held prior to the outcomes of the MEPC 76 session

DNV has launched the EEXI Calculator to support customers in ensuring their compliance with the latest regulations Source: DNV

Classification society launches digital EEXI tool

SELF-SERVICE | A new digital tool for shipowners and operators to gauge their ships' compliance with the IMO's energy efficiency existing ship index (EEXI) has been launched by DNV. The EEXI Calculator was unveiled on the closing day of the IMO's MEPC 76 meeting, at which the new regulation, together with the carbon intensity indicator (CII), were both adopted. The indices, which address the energy efficiency and carbon footprint of existing vessels, will enter force in January 2023.

DNV estimates that up to 30,000 vessels could be required to take action to comply with the EEXI. Many of these ships are likely to be older units built before the focus on engine performance, fuel consumption and overall energy efficiency became ship design priorities.

A key component in the IMO's ambition of reducing shipping's carbon emissions by 40% by 2030 compared with 2008 levels, the EEXI focuses on the design of existing vessels, rather than their operation, which is addressed by the CII. The EEXI estimates carbon dioxide emissions in relation to installed engine power, transport capacity, speed, and energy efficiency. The index will apply to all internationally trading cargo ships and cruise vessels of more than 400gt, depending on their propulsion type.

The EEXI Calculator is available on the classification society's Veracity data platform and has been designed for shipping's high-volume sectors including bulk carriers, tankers and container ships. Based on information uploaded by the user, the tool produces a ship-specific technical file and an EEXI calculation.

For owners whose ships meet the EEXI benchmarks for existing vessels, they will have the EEXI calculation on file. However, the tool will also highlight ships for which remedial action is needed. In these cases, DNV's advisory experts can work with customers to decide on a strategy for compliance and prepare the necessary documentation, the classification society said.

Fabian Kock, DNV Maritime's head of Section Environmental Certification, explained: "These two pathways are designed to help everyone tackle their EEXI challenges in time to reach compliance. For companies with a younger fleet, this may not require major adjustments; they can easily access and prepare the required documentation through our EEXI calculator.

"And for those who need more support, there is the opportunity to tap into DNV's extensive expertise as they prepare to make more involved decisions around how their vessels can meet the regulatory requirements and secure EEXI compliance when the regulation comes into force."

A "green" option for tank degassing

NANOVAPOR | US-headquartered Ecochlor has developed a technology that it says offers a simple way for seagoing tankers and inland barges to degass tanks. The NanoVapor system allows for safe entry to enclosed spaces or preparatory work at repair yards or ship recycling in less time, at less cost and without generating extra hazardous waste material.

"In the old days it was customary just to open the lids of tanks that contained oil and petrochemicals and vent the headspace to the atmosphere. Apart from product residues, this required a safe handling of the explosive volatile organic compounds (VOCs) present in the tank's headspace. Health and safety concerns for the crew as well as stricter environmental regulations now require different solutions," said Sören Scheid, Ecochlor's regional business development manager and brand manager for NanoVapor.

One such solution is the use of mobile or stationary flares. These flares can alleviate pollution from VOCs but they come with the cost of increased CO_2 emissions from incineration, Scheid explained.

The NanoVapor system allows for safe and sustainable degassing of tanks Source: Ecochlor

Powered purely by compressed air, NanoVapor produces a fine spray of the patented BargeSafe™ fuel vapour suppressant, which is directed into the tank. The active substance settles on the residual tank content (generally hydrocarbons with C>5) and forms a molecular barrier which stops further evaporation for up to several days. The VOC concentration in the headspace is quickly reduced to safe levels with respect to explosion hazard (LEL) and occupational exposure limits (OEL). BargeSafe is non-hazardous, biodegradable and does not create any additional sludge or waste material, Ecochlor noted.

Consequently, environmental contamination with VOCs, health and explosion risks as well as degassing time and carbon footprint are significantly reduced while always maintaining safe oxygen levels inside the tank.

Governments commit to ambitious zero-emissions drive

INITIATIVE | The governments of Denmark, Norway and the United States, supported by the Global Maritime Forum (GMF) and the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, have launched a new initiative, Zero-Emission Shipping Mission, to decarbonise shipping's supply chain. A statement issued by the GMF on behalf of the partners implied that more urgency in shipping's decarbonisation drive is required.

The initiative is part of Mission Innovation, originally launched at COP21 in 2015. Its second phase – MI 2.0 – was unveiled at the Innovating to Net Zero Summit in Chile at the beginning of June. The aim of its 22 country members and the European Commission is to stimulate more attention on, and investment in, clean energy.

The Zero-Emission Shipping Mission aims to accelerate international public-private collaboration in new green maritime developments, all with a zero-emission course as the heading. The Mission is also supported by the governments of France, Ghana, India, Morocco, Singapore, South Korea and UK.

The Mission has three main goals:

- To develop, demonstrate, and deploy zero-emission fuels, ships, and fuel infrastructure in a coordinated fashion along the full value chain;
- By 2030, to have ships capable of running on hydrogen-based zero-emission fuels—such as green hydrogen, green ammonia, green methanol, and advanced biofuels—make up at least 5% of the global deep-sea fleet measured by fuel consumption;
- By 2030, to have at least 200 of these well-to-wake zero-emission fuelled ships in service and using these fuels across their main deep-sea shipping routes.

Simon Kollerup, Danish Minister for Industry, Business and Financial Affairs, commented: "In Denmark, we believe a greener future is possible – if we work together. As one of the world's largest maritime nations, Denmark has initiated the Zero-Emission Shipping Mission with great partners from the public and the private sector from all over the world. Our common goal is to make zero-emission vessels the natural choice for shipowners when they renew their fleets."

Norway's Minister for Climate and Environment, Sveinung Rotevatn, said: "The decarbonisation of shipping will result in a growing global demand for climate technology in the years ahead. Norway's and other countries' leading position in green shipping can become an important competitive advantage, giving the maritime industry huge growth potential in international markets."

Speaking for the United States, Secretary of Energy, Jennifer Granholm, declared: "Through fearless technological innovation, ambitious clean energy deployment, and constructive international collaboration, we can build a net-zero carbon economy that creates millions of jobs and lifts our citizens into greater prosperity."

The Global Maritime Forum's Johannah Christensen, managing director, said that shipping is on the verge of a clean energy revolution. "To set the global maritime industry on a climate-aligned course and meet the goals of the Paris Agreement, zero-emission vessels need to be the dominant and competitive choice by the end of this decade. The Zero Emission Shipping Mission will accelerate public and private efforts around the world to make a zero-emission fleet a reality by 2030."

Summing up, Bo Cerup-Simonsen, CEO of the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, said: "The shipping industry needs to decarbonise to be part of the solution to the climate crisis. It will not be easy, and we don't have a lot of time, but it is possible and now is the time to act. The Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping is all about accelerating the transition by finding solutions through collaboration with partners across the ecosystem. With our partners we are proud and excited to co-lead this very important Zero Emission Shipping Mission."

What will the shipping industry look like in 2050?

STUDY By 2050, shipping must cut its CO_2 emissions by at least half, even after accounting for world fleet growth. In a joint study, MAN Energy Solutions and the Fraunhofer Institute have developed four scenarios that demonstrate how the shipping industry might develop by 2050.

The International Maritime Organization's (IMO) regulations require shipping's carbon footprint to be reduced by at least 50% by 2050, compared with 2008. At the same time, the projected increase in shipping emissions is being driven by growth in international trade. The IMO predicts that shipping emissions could grow by between 50 and 250% by 2050, based on various industry-growth scenarios. Thus, international shipping needs to solve the dilemma of reducing its carbon footprint while still growing business.

"The maritime industry currently has a goal, but not yet a way to get there," said Dr Uwe Lauber, CEO of MAN Energy Solutions. "By 2050, the International Maritime Organization wants greenhouse gas (GHG) emissions to fall by 50%: however, these targets have not yet been backed up by concrete measures." Lauber stressed: "Time is pressing – 2050 is just a single ship generation away."

MAN Energy Solutions recently commissioned a study from the Fraunhofer Institute on the future of the shipping industry whose researchers developed holistic scenarios that incorporate a long-term view leading up to 2050. These scenarios take into account all relevant factors affecting the transition process, including changes in lifestyle and thinking, economic growth, regulation, and digitalisation. The '#AHOY2050 study' outlines four scenarios that explore how to reach the maritime industry's climate targets by 2050, but also consider the failure to do so.

"Our main aim with #AHOY2050 is to provide food for thought and stimulate discussion. We are a long way from knowing all the answers. It is crucial, however, that we encourage the debate on how shipping can achieve its climate targets. Because one thing is clear: we are running out of time," said Lauber.

#AHOY2050 therefore approaches shipping as part of a global ecosystem. Beginning with societal awareness of the problem and the importance of climate protection – and extending it to commodity prices, global economic development and Covid-19 – a multitude of factors impact global shipping. Lauber said: "It is these interrelationships that will largely determine how resolutely the maritime energy transition is pursued."

In order to develop scenarios, the study looks at what experts consider to be the 13 most relevant, influencing factors. On this basis, the Fraunhofer researchers then developed four outline scenarios. To verify the results, #AHOY2050 also gathers weighty voices from the industry and beyond. For the qualitative part, the Fraunhofer Institute interviewed some 40 experts from all areas of the maritime industry, but also from associations, and the fields of science and politics. Over 30 industry experts subsequently discussed the scenarios drafted on this basis in a workshop.

Four scenarios for the future of shipping

The final scenarios are entitled: 'All on Board', 'Hanging on to Old Ways', 'Out of Control' and 'Yes We Can?':

- **A – All on Board:**
  In Scenario A, the IMO objectives are achieved within the target timeframe and a major step toward a carbon-neutral future has been taken. In addition, the challenging climate policy targets from the United Nations Framework Convention on Climate Change (UNFCCC) are reached to achieve 2°C climate stabilisation. Technological change has created a clear, competitive advantage for the shipping industry and acts as a driver for growth.
- **H – Hanging on to Old Ways:**
  In Scenario H, climate-change policy continues to be supported by a limited number of countries only and the shipping industry fails to reach IMO climate targets. As a result, the division within society widens with conflicts between the groups in favour and those against the targets. Left to their own devices, markets fail to drive true, technological change and carry on with business as usual. For shipping, this means that liquefied natural gas (LNG) becomes the main alternative to heavy fuel oil (HFO) and diesel fuels, since it does not require great changes to operations or behaviour.
- **O – Out of Control:**
  In Scenario O, IMO objectives fail to implement the decarbonisation of shipping and reduction of GHGs systematically, and only a few stakeholders are driven by the impact of climate change. Simultaneously, the development of low-carbon fuels (LCF) stagnates, while the shipping industry focuses on increasing the efficiency of fossil-fuel technologies and benefits from low oil prices and economic growth. Consequently, society turns away from a sustainable lifestyle and, with a lack of support from most governments, climate policy to achieve GHG mitigation fails.
- **Y – Yes We Can?:**
  In Scenario Y, the challenging climate-policy targets from the UNFCCC and IMO objectives have been exceeded by 2050. As such, low-carbon technologies for shipping become part of standard operation, while changes in global culture result in a sluggish or even shrinking economy where climate change and a sustainable lifestyle have become priorities. Alternative targets to conventional economic growth are developed and there is no 'catch-up' by developing countries.

In summary, Scenarios A and Y show that global regulations for reducing environmental impacts have the potential to drive massive, technological change in shipping, and that such regulation is heavily driven by public opinion. In contrast, scenarios H and O show that – left to its own devices – technological development is

more likely to focus on maximising efficiency and driving down costs. Here, there would still be a switch to LNG and some resulting reduction in emissions, but the switch to renewable fuels will simply not happen unless the world makes a conscious decision to drive this strategy.

Five lessons from #AHOY2050

"Mapping scenarios is not about predicting the future," said Dr Lauber, "but they can offer some guidance and help to identify trends or point in a general direction. Probably the most disruptive action suggested by the scenarios is that, from a certain point on, we may have to consider a complete ban on fossil fuels in shipping. Such a step is a striking parallel between both scenarios in which climate goals are achieved".

However, there are five important insights that MAN Energy Solutions believes are relevant for the shipping industry's ongoing discussion on how to make decarbonisation happen:

Lesson 1: Decarbonisation needs global regulation

If there is no international agreement that adopts a stringent climate change mitigation policy in the short to medium term, current emissions legislation for NOx/SOx will lead to the growth of LNG as an alternative fuel. A comprehensive shift toward carbon-free fuels would then not take place and climate targets would be missed. LNG and other low flashpoint fuels can act as bridging technology for green, hydrogen-based fuels like ammonia in replacing fossil fuels. A global agreement to mitigate climate change and strong political support for the development and use of low-carbon fuels could pave the way for such a transitory pathway.

Lesson 2: Rapid action is required

Large-scale decarbonisation can be achieved in shipping by 2050. However, this will require rapid action to make low-carbon alternatives the technologies of choice for the majority of ships by at least 2035. Along with new propulsion systems for newbuildings, this will include a major retrofit market as well as the development of new bunkering infrastructure.

Lesson 3: Decarbonisation can act as a driver for growth

In an increasingly globalised world, only green shipping can cover the growing demand for international logistics – if decarbonisation is a global priority. Shipping will be of fundamental importance for this global economic growth. In terms of emission reduction, shipping has clear advantages over other transport vehicles in that ships are large and heavy enough to permit the use of alternative low-carbon-energy technologies even if the energy density of the propulsion plant and fuel is reduced. Hence, shipping can become more competitive with air cargo and passenger transport.

Lesson 4: Public opinion matters

Regulation is the engine for rapid change. Its driving force, however, is public opinion. Successful decarbonisation depends on the majority of the world population buying into a sustainable lifestyle. The global community must support regulation and also be prepared to invest in low-carbon technologies.

Lesson 5: Decarbonisation and digitalisation are autonomous trends

The shipping industry will undergo a process of digital transformation with many benefits, including significant progress in autonomous shipping. While the digitalisation trajectory is not linked to the progress of decarbonisation, it can facilitate the latter – notably through new possibilities for control and optimisation.

A wake-up call for the shipping industry

MAN Energy Solutions sees the #AHOY2050 study as a critical wake-up call. "With shipping, everyone always talks about the technical side. Technically, however, the maritime energy transition has long been feasible. For years, the challenge has been at the political and an overall, societal level," said Lauber, summing up the situation. "Today, we can build engines that run on zero-emission fuels, but making the decision to ramp up synthetic and carbon-free fuels in the market is not something we can do alone."

Therefore, in Dr Lauber's view, a clear political course and global regulation are the key parameters for a successful, maritime energy transition: "If the world becomes entangled in selfish interests, we will not achieve a climate turnaround. In contrast, a smartly-set, global, regulatory framework can turn the decarbonisation of shipping into a growth engine for the industry. After all, if the global supply chain is consistently geared toward climate protection, ships are far superior to all other modes of transport."

The complete study and all four scenarios are available for download at https://www.man-es.com/ahoy2050.

Methanol's potential for greener shipping

APPLICATION SCENARIOS Methanol offers significant potential for reducing emissions and can provide a straightforward, regulated transition for the shipping industry. Ongoing research is aiming to scale up infrastructure availability on and offshore, writes Panos Koutsourakis, ABS director of Sustainability Strategy, Singapore.

A number of alternative fuels are under consideration as a means of reducing carbon emissions in shipping. Of these, methanol is one of the two principal options currently available to shipowners, with methanol-powered vessels already in service, further ships under construction and numerous development projects underway.

Available worldwide and used in a variety of applications for many decades, methanol is most commonly produced on a commercial scale from natural gas. However, it can also be produced from renewable sources such as biomass or electrolysis powered by renewable power and supported with carbon capture utilisation technology.

Either production pathway, blended into conventional methanol in increasing volumes, could considerably reduce shipping's CO_2 footprint. This potential – as well as its ability to provide compliance with IMO 2020 regulations – means that application of methanol is drawing wider interest from owners of oceangoing vessels, short-sea ships, ferries, cruise ships, and inland waterway vessels.

Properties

Methanol is a colourless liquid at ambient temperature and pressure, with a characteristic pungent odour. It is easier to store and handle than LNG, ammonia or hydrogen, and so it presents fewer challenges as a marine fuel than these other options. Its properties are shown in Figure 1.

The chemical has the highest hydrogen-to-carbon ratio of any liquid fuel, a relationship that potentially lowers CO_2 emissions from combustion when compared with conventional fuel oils. When used as the primary fuel, methanol can reduce CO_2 emissions by around 10%, and has the potential to be a carbon-neutral fuel in the future if produced by renewable means through biomass/biogas or renewable electricity.

Like LNG, it is of course a hydrocarbon, but it has a much lower specific energy content – 19,700 kJ/kg – compared with LNG and other conventional liquid fuels. For the same energy content, methanol requires about 2.54 times more storage volume than conventional fuels. When comparing methanol with LNG, an overall decrease in the effective volumetric density of LNG should be taken into account for cargo tanks, insulation and filling factors, boil-off gas, and custody transfer losses.

METHANOL PROPERTY	VALUE
Energy density (MJ/L)	15.7
Heat of vapourisation (kj/kg)	1,098
Autoignition temperature (°C)	450
Liquid density (kg/m³)	798
Adiabatic flame temperature at 1 bar (°C)	1980
Molecular weight (g/mol)	32.04
Melting point (°C)	-97.8
Boiling point at 1 bar (°C)	65
Critical temperature (°C)	239.4
Critical pressure (bar)	80.48
Flammable range in dry air (%)	6 - 36.5
Cetane number	< 5
Octane number	109
Flash point (°C)	12
Heavy Fuel Oil (HFO) equivalent volume	2.54

Figure 1: Methanol properties Source: ABS

Methanol has significantly less impact if spilled or leaked into the environment than conventional hydrocarbon fuels. It dissolves readily in water, and only very high concentrations in the environment create lethal conditions or any detrimental impact on local marine life.

This means that a methanol spill would result in limited damage to the environment except for the release of carbon into the marine ecosystem. Methanol in the ocean is common, produced naturally by phytoplankton, and is readily consumed by bacteria microbes, thus entering and supporting the food chain.

Regulatory approval

The general safety principles of the IMO's IGF and IGC Codes provide the framework for the use of low-flashpoint marine fuels such as methanol. Common safety principles such as fuel tank protective location, double barriers on fuel supply lines, ventilation and gas detection, hazardous area classification, explosion mitigation, etc. are equally applicable to all low-flashpoint fuels.

However, individual fuel characteristics may require specific safety features. For methanol, any fuel leaks produce heavier-than-air vapours requiring additional detectors because the fuel is toxic if ingested or inhaled. The fuel characteristics would be considered during the risk assessment analyses.

The adoption of IMO Interim Guidelines for the Safety of Ships Using Methyl/Ethyl Alcohol as Fuel in November 2020 covers considerations for ship design and arrangement, fuel containment system, materials, pipe design, bunkering, fuel supply, power generation, fire safety, explosion prevention, hazard area classification, ventilation, electrical installations, control systems, crew training and operations.

Methanol does not have cryogenic complexity and is a liquid at ambient conditions. It is a widely traded commodity with an existing global distribution network that could be leveraged to support marine fuel bunkering. In addition to having been traded and transported in chemical carriers for many years, there is also a wealth of experience of offshore support vessels and platform supply ships handling methanol for the offshore industry. This provides further reference points for the wider adoption of methanol as a bunker fuel.

Vessel applications

Adoption of low carbon and net carbon-neutral fuels for large vessels is more challenging than for smaller ones. Using fuels

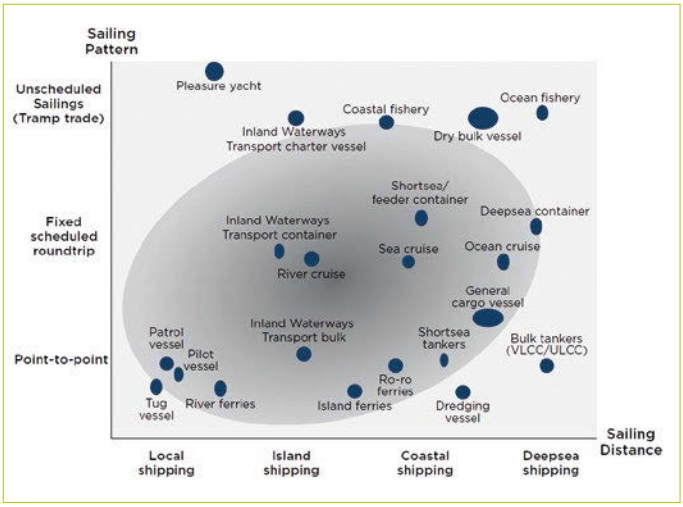


Figure 2: Heatmap of methanol applicability by vessel type
Source: http://resolver.tudelft.nl/uuid:7bccc026-6f42-4948-91b8-cd585f58d21c

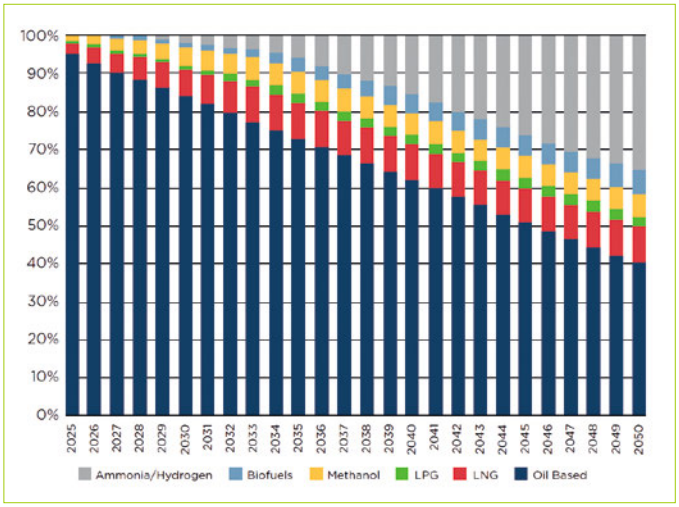


Figure 3: Projected fuel use by 2050

Source: ABS

with low energy fuels like methanol would require a significant redesign, not least because fuel tanks would need to be expanded to store enough energy for longer deep-sea travel.

However, methanol is more suited to storage in near conventional fuel tanks so it would be easier to accommodate than other low-flashpoint fuels. Under MSC.1/Circ.1621 5.2.1, it may be bounded by the vessel shell plating when located below the lowest possible waterline.

The trade and regulatory landscape of short-sea vessels make them ideal candidates for early adoption of new technologies such as methanol. The fuel has strong potential to lower the shipping's carbon footprint, but one its main drawbacks is its low energy density.

That said, compared with other potential fuels, methanol is relatively efficient at energy storage by volume based on physical tank space. Short-sea ship operations could be well-suited to methanol as a fuel, because such vessels can take on bunkers more frequently.

Research projects are proceeding on land before testing at sea. They include tests on engines fuelled by either pure methanol or a methanol mix. Other research projects are focusing on scaling up methanol to become available for use in the wider transportation industries.

For use in marine applications, infrastructure such as methanol bunkering facilities and fuel supply systems are to be developed. A partnership between Copenhagen Airports, A.P. Møller-Maersk, DSV Panalpina, DFDS, SAS, and Ørsted has been established to scale up the production of industrial hydrogen in Denmark, with the aim of producing sustainable fuel for the road, air, and marine transportation networks by 2030.

Near-term potential

The benefits of reduced emissions from burning methanol could be a significant contributor to reducing shipping's greenhouse gas emissions. Existing methanol trade infrastructure can also be an important factor for the cost and availability of methanol over other marine fuel options.
One of the main challenges to owners during this fuel transition is to decide on an alternative fuel to prepare for 2050. Early adoption of such fuels depends on the demand and supply landscape. In the case of methanol, even though its trade has developed, its demand in manufacturing and industry may not allow surplus for maritime use without incentives.

Due to this widespread use of methanol across the globe, the marine industry can at most claim a fraction of the amount available unless methanol is produced synthetically. However, synthetic methanol is likely to be more expensive.

Methanol carriers already use a small volume of their cargoes for propulsion and power generation. Now, the development of efficient propulsion systems is offering potential for its application in other types of newbuild cargo vessels. If it is produced by renewable means, these vessels could offer even greater potential to reduce life cycle emissions while also improving the renewable fuel supply chain for other applications.

The use of methanol as a fuel in dual-fuel marine engines may allow for robust operations with various types of fuels in the future. Such applications may use methanol when it is available, with the option to burn other fuels depending on convenience and economics.

Ongoing research is striving to scale up methanol availability rapidly in terms of infrastructure as well as shipboard applications and installations. Figure 3 shows projected marine fuel use to 2050 as the industry strives to meet the GHG emissions-reduction targets mandated by the IMO.

European logistics operator flies flag for biofuels

AGREEMENT | Rotterdam-based multimodal logistics company, Samskip, has signed an agreement with sustainable shipping specialist, GoodShipping, to operate a steadily increasing number of its ships on biofuels. The initiative has begun with biofuel for the 800-TEU container ship *Samskip Endeavour*, which is expected to log a CO_2 emissions reduction of 45%. Later this year, however, a scaling up of the programme is targeting an 80% cut in CO_2 emissions as more Samskip vessels join the scheme.

Under the terms of the agreement, biofuels supplier, GoodFuels, will provide the bunkers, which are produced from certified feedstock, labelled as waste or residue. The initiative is likely to confound many biofuel critics who question the source and raw material from which some biofuels are derived. Produced from sustainable waste streams, there are no land-use issues, no competition with food production, or deforestation during the production process, the companies said. The fossil-free biofuel has already proved a success during trials aboard the *Samskip Endeavour* between the Netherlands and Ireland.

GoodShipping's Commercial Lead, Katarin van Orshaegen, declared: "The announcement marks yet another milestone in our journey beyond the fossil default. Reducing fuel emissions and consumption is a vital next step for the maritime transport industry, so we are extremely pleased to have found a stable fulfilment outlet for our sustainable cargo streams with Samskip, deepening a long-term partnership that is helping to change the way our market thinks about future fuels."

Ásbjörn Gíslason, Samskip Deputy CEO and CCO, commented: "We take great pride in and welcome the collaboration with GoodShipping to strengthen our deep partnership, becoming one of their fulfilment and innovation partners. By playing a forward-thinking and pioneering role in the energy transition, our customers can now benefit from a simple and easy means of decarbonising their cargo streams. We get to pioneer advanced marine biofuels, and the environment benefits from an immediate carbon reduction."

Source: Samskip

The *Samskip Endeavour* is the first ship in the programme to run on biofuel

Methanol fuel cell system to undergo tests in Denmark

AUXILIARY POWER | A methanol fuel system intended as a source of auxiliary power for ships and offshore assets is to be tested at the Alfa Laval Test & Training Centre in Aalborg, Denmark. The project, funded by Denmark's Energy Technology Development and Demonstration Program, is a joint initiative between fuel cell manufacturer, Blue World Technologies, Alfa Laval, and asset owners DFDS, Hafnia and Maersk Drilling.

The aim of the project is to test a fuel cell, based on high-temperature proton exchange membrane (HTPEM) technology, that could provide a realistic alternative to conventional auxiliary engines in the near future. The fuel cell to be tested will have a power of 200 kW, but the system is designed to be scalable up to 5 MW, the companies said.

The fuel cell setup will be based on carbon-neutral renewable methanol, with no particulate emissions. Methanol, seen as one of the most promising fossil-free marine fuels of the future, is already being tested at the Alfa Laval Test & Training Centre. However, other fuels including LNG and ammonia could also be used in the fuel cell technology in the future.

There are various issues to investigate during a year of tests. For example, fuel cell durability and longevity are key issues requiring careful analysis of performance degradation over time. HTPEM fuel cells have a higher tolerance for thermal cycling than other fuel cell types, however, meaning that they should be well suited to the varying power requirements of ships' gensets.

Cost is another important issue. Blue World Technologies is currently engaged in structuring its business for the mass production necessary to enable fuel cells to compete with the conventional combustion technologies used in auxiliary engines today.

Blue World Technologies' co-founder and COO, Mads Friis Jensen, commented: "Building on the scalability of automotive applications, we are convinced that methanol fuel cell systems can drastically reduce maritime climate and environmental impact. By further developing our technology in partnership with marine colleagues, and by ramping up our production capacity at the same time, we can deliver a fuel cell solution that is green, operationally sound, and also commercially viable."

The project's three asset-owning partners are all positive about the potential for fuel cells in their operations. Jakob Steffensen, Innovation Lead at DFDS, commented: "Fuel cells have the potential to expedite the green transformation of shipping. The technology will enable a new generation of very simple and reliable ships that will be much easier to digitise than the ships we have today."

Hafnia's vice president, Technical, Jørgen Thuesen, revealed that the company is already a strong supporter of methanol. "We have invested in a methanol plant project, and the current research project is yet another significant effort. We will apply our practical knowledge of methanol to assist in creating a green and competitive fuel cell solution," he said.

Emphasising that energy efficiency is a key focus at Maersk Drilling, the company's head of Integrity & Projects, Caroline Alting, declared: "In the HTPEM fuel cell system, we see clear potential as an enabler in creating a climate-friendly solution for power production. We believe our application knowledge and operational input can help to shape a well-adapted marine solution."

Chinese fuel cell awarded type approval

CCS | Wuhan-based fuel cell developer, Troowin Power System Technology Co, has been awarded type approval by China Classification Society (CCS) for its hydrogen proton exchange membrane (PEM) fuel cell. The development paves the way for real-time tests on a purpose-built 2,100dwt bulk carrier, said Jia Siqing, general manager of Industrial Products at CCS Wuhan branch.

The bulk carrier, still at the design stage, is expected to operate using four 130-kW hydrogen fuel cells and will be tested on the Pearl River in Guangdong province. The data collected from these trials will be combined with similar findings from other sectors including the country's electric vehicle sector.

One key issue highlighted by Jia is the challenge of storing sufficient hydrogen for a vessel to undertake a deep-sea voyage. The classification society is looking at ways to store hydrogen in large volumes and combine it with other power sources to extend range, he said.

"Since hydrogen is the lightest natural element, more space is needed to store it," he explained. "We are looking at methods to create hydrogen at sea, such as the use of methanol or ammonia, which can be transported easily and cheaply. But the main focus of our work is carrying enough bulk hydrogen for an entire voyage. We think liquid hydrogen would be a good contender for this. In the meantime, high-pressure gas cylinders would be a reasonable solution."

Luo Xiaofeng, a colleague of Jia, is director of CCS Rules & Research Institute in Wuhan. He emphasised the critical importance of safety in the Pearl River tests. "CCS is working with other hydrogen-use sectors and universities to share the research, notably the automotive industry. Breakthroughs elsewhere can help the marine industry. Safety is absolutely key to developing a commercial case. These are the prime factors we will be testing on the Pearl River project."

Luo conceded that in the short term, low-carbon and hybrid systems offer better options for deep-sea voyages but that is why storage technology is so important. The use of hydrogen should be focused on new, purpose-designed ships rather than retrofits, he said, from a safety point of view.

CCS is also engaged in research on the possible use of hydrogen as fuel with China State Shipbuilding Corporation. The research is focused on risk assessment, ventilation, and fire-fighting. The classification society has been authorised by the China Maritime Safety Administration to develop the first regulations for ships using hydrogen fuel and these are expected to be released around the end of the year.

The country's President Xi told the United Nations General Assembly in a remote meeting last September that China aims for CO_2 emissions to peak by 2030 and to achieve carbon neutrality by 2060.

Heavyweight partners to develop ammonia-powered gas carrier

NOGAPS | The Global Maritime Forum (GMF) and Fürstenberg Maritime Advisory (FMA), a consultancy, have brought together a group of partners representing shipping's value chain to develop a concept for a zero-emissions gas carrier powered by green ammonia. The Nordic Green Ammonia-Powered Ship (NoGAPS) project aims to demonstrate that green ammonia offers significant potential in maritime decarbonisation by developing "a credible business model", GMF said.

The partners will work on a concept that envisages a gas carrier powered by green ammonia – in other words, ammonia that is produced by completely sustainable and carbon-free means. The vessel will transport ammonia as a cargo in the north European region.

Although there are many initiatives underway as shipping's decarbonisation programme becomes increasingly urgent, the development of zero-carbon fuels is still some way off. However, GMF highlighted recent research demonstrating that zero-emission fuels need to make up 5% of shipping's global fuel mix by 2030 if the industry is to stand a chance of meeting mid-century decarbonisation targets.

Partners in the NoGAPS consortium include BW Epic Kosan, Danish Ship Finance, DNB, DNV, MAN Energy Solutions, Ørsted, Wärtsilä and Yara International. Nordic Innovation, meanwhile, which promotes Nordic business initiatives, is co-funding the project.

Early conclusions drawn by the NoGAPS partners in relation to the vessel, the fuel, the fuelling options, and the business model are:

- The potential of green ammonia-powered shipping to contribute to the decarbonisation of the maritime sector is significant, and ammonia carriers present a logical starting point for demonstrating this potential;
- Neither the technical considerations nor the associated regulatory approval for a green ammonia-powered vessel present major obstacles to putting the *m/s NoGAPS* on the water;
- Ammonia synthesised from green hydrogen represents a credible long-term, zero-emission fuel;
- The most important challenge to be overcome is to develop and demonstrate a business model that is credible in the eyes of investors and operators. Both the vessel design and the fuel sourcing strategy offer opportunities to reduce risks and costs in meaningful ways;
- Government support and public finance can both accelerate the short-term timetable for investment in demonstration and improve the outlook for long-term deployment of green ammonia as a shipping fuel.

GMF's Jesse Fahnestock, project director, said: "Understanding the technologies and business models needed to deliver zero-emission shipping is key. The NoGAPS concept study examines the full value chain viability of powering ships with green ammonia. It finds that using green ammonia as a fuel is both practical and feasible. Focus should now be on measures that can strengthen the business case for zero-emission ammonia."

Speaking on behalf of Yara Clean Ammonia, president Magnus Ankarstrand, commented: "There are no significant technical barriers towards large-scale green zero-carbon ammonia production and ammonia can be delivered at scale reliably and safely to the shipping industry. Yara, as a leading ammonia player, is planning to set-up large-scale green ammonia production in Norway and other regions. All stakeholders including the regulators, governments and environmental agencies should act now to enable the shipping industry to transition towards green ammonia as a fuel. The NoGAPS concept study has proven the viability and credibility of green ammonia as a shipping fuel and Yara believes that collaboration across industries will remove barriers to making this a reality."

BW Epic Kosan's Hans-Henrik Ahrenst, performance manager and naval architect, added: "We have found the NoGAPS study to be an interesting and valuable process, as it has brought together the entire value chain – for example, ammonia producers, energy providers, ship designers, rule makers and engine manufacturers alongside financial institutions – to explore the possibilities of ammonia-powered vessels. One key finding of the study is that it is possible to use green ammonia as a natural choice of fuel for an LPG carrier. There are still areas to be explored, but NoGAPS has taken some big steps along the path to ammonia-powered shipping."

Biofuels comparison initiative

JIP | The d'Amico Group is leading a joint industry project (JIP) to test the performance of B30 biofuel blends derived from advanced second-generation feedstock on board its 74,999dwt product tankers, *Cielo Bianco* and *Cielo di Rotterdam*.

The aim of the JIP is to use well-to-wheel analysis – from raw material acquisition to combustion aboard the tankers – to compare the performance of the biofuel with traditional fossil fuels.

D'Amico's partners in the project are ABS, Liberian Registry, Lloyd's Register's Fuel Oil Bunker Analysis Advisory Service (FOBAS), MAN Energy Solutions, RINA and Trafigura.

The project will also focus on the stability and degradation of the B30 biofuel in storage, and its NOx emissions in relation to the Tier II certification of the ships' engines. The fuel will also be assessed for its performance in relation to the IMO's short-term measures – EEXI and CII.

The biofuel will be supplied by bunker company, TFG Marine, in the Amsterdam-Rotterdam-Antwerp region.

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Major scope for emission cuts

SHORE POWER Cruise and ferry ports have been amongst the first to invest in shore-to-ship energy facilities. But shore power is climbing the regulatory agenda and is likely to become mandatory across other sectors of shipping in the years ahead. Experts claim that clean electricity has significant potential to boost shipping's decarbonisation drive, writes freelance journalist Paul Bartlett.

Shore power is on the rise in European ports Source: ABB

Short and intensive port calls for ferries and high hotel power demands from cruise ships are the main reasons for ports which handle such vessels to pioneer shore power systems. But as shipping's emissions and the sector's performance on sustainability is now under the spotlight, there is huge potential to clean up shipping's power needs in port generally, particularly if shore power comes from renewable sources.

At most ports and terminals, ships still start up their diesel-powered generators to provide energy for cargo handling, heating, ventilation, and other shipboard consumers. But the auxiliary engines that are used in port are often relatively old and inefficient, kicking out carbon-laden smoke – as well as other toxic emissions – often in locations close to populous areas. They are seen as posing significant threats to the environment and the health of vulnerable people.

An independent study conducted some time ago by consultancy Ricardo Energy & Environment concluded that carbon emissions from large vessels during UK port calls amounted to 2.6% of total emissions from the country's transport network, and 16% of those generated by shipping. Although the study was completed in 2018, not much has changed at UK ports since then.

Electrifying progress

Elsewhere, the drive for shore power is gathering pace. In California, for example, cruise ships, container ships and reefer vessels must already comply with shore power regulations, but tighter rules are due to be introduced in 2023. From 2025, car carriers and tankers will also need to comply with shore power requirements.

A series of European ports are also initialising shore power including Bergen, Bremen, Flåm, Gothenburg, Hamburg, Karlskrona, Kiel and Oslo. And it is not only ports, but also some of their customers who are keen to adopt more sustainable energy strategies.

Ferry lines are front-runners: Color Line, Stena Line and Viking Line are amongst the ship operators which have invested in systems from shore power suppliers including ABB, Igus and Siemens. Ferries are ideal candidates, deployed on fixed routes and set timetables, making shore connection arrangements an obvious choice and payback periods relatively easy to calculate.

The economics stack up both for shoreside power suppliers and for their customers, according to Peter Selway, UK Marketing manager for Schneider Electric, another system provider for electricity from shore. Not only is power from the shoreside gride invariably cleaner than energy generated by ships, but it also cheaper, providing ports with an opportunity for a small margin on price while still providing ship operators with lower-cost energy.

Selway reveals details of a shore connection facility installed in the Orkney Islands for the RoPax ferry, *Hamnavoe,* which is believed to be the UK's first shore-to-ship power project. The vessel, operated by NorthLink, provides a vital link between Stromness, Orkney and mainland Scotland. The connection has cut the ferry's fuel consumption by more than 500 tonnes a year, and maintenance costs have fallen sharply. At the outset, the project was estimated to pay back in about three years.

German focus

Meanwhile, in Germany, the State Government of Hamburg has given the go-ahead to the city's port for a EUR 76 million expansion in shore power, making it available to cruise ships and large containerships from next year. Shore power will be available from eight connection points at Burchardkai, Europakai and Predöhlkai, as well as all of the port's cruise terminals.

Stena recently revealed details of its Stena Elektra project, in which it plans to have a battery-powered ferry operating between Gothenburg and Frederikshavn, Denmark, before 2030 Source: Stena Line

The *AIDAsol* is the first cruise ship to use the new facility in Rostock Warnemünde; the photo shows the official inauguration of the plant Source: AIDA Cruises

The Port of Kiel aims to provide 60-70% of visiting ships' energy demand from shore within the next two years. A new connection allowing two ships to connect simultaneously was inaugurated at the Ostseekai in December, supported by the state of Schleswig-Holstein (EUR 8.9 million) and the EU (EUR 1.26 million).

The Siemens system follows an earlier plant, installed at the port's Norwegenkai, with energy supplied to two large Color Line ferries operating from there to Oslo. The two ships have an estimated energy requirement of about four million kW/h a year in Kiel and this is now met with green electricity from shore.

In May, as part of the 12th National Maritime Conference, Europe's largest onshore power plant was commissioned in the port of Rostock-Warnemünde. The shore power plant in the port was completed in 2020 and can supply up to two cruise ships with electricity while they are in port. With a maximum power capacity of 2 x 16 MW, this makes it the largest plant in Europe.

Stena's ambitions

Shore power in Kiel has enabled Gothenburg-based Stena Line to continue with its strategy of using more electricity from shore. Its ferries, *Stena Germanica* and *Stena Scandinavica* now use shore power at terminals in Gothenburg, Karlskrona, Norvik, Trelleborg, and Hook of Holland. Fourteen of the ferry line's 36-ship fleet are fitted with high voltage shore connection systems.

The company is one of a handful of pioneers in shipping's sustainability drive. Already, it claims to be ten years ahead of international maritime emission targets but is still planning to cut emissions of CO_2 by nearly a third in absolute numbers between now and 2030.

Erik Lewenhaupt, the ferry company's head of Sustainability, explained recently: "It is a balance between our customers' expectations, legal requirements on the horizon and our own level of ambition. When we crunched the numbers and figured out what we could manage with known technologies and a lot of work, we found that we could reduce emissions by 21%. "But our ambitions are higher than that," he declared. "To reach 30%, we need to take some serious actions and explore all possibilities."

The company has a four-point plan based on alternative fuels, electrification, fleet modernisation and changes to behaviour.

Joint development of ESS

AGREEMENT | Vancouver-based battery technology specialist, Sterling PlanB, and the International Contract Engineering (ICE) design group, headquartered in the Isle of Man, have signed a cooperation agreement to work on energy storage system (ESS) development and take-up of the technology in shipping. In a statement, the companies declared that their unique combination of complementary understanding and experience should provide an optimised and integrated route for adopting ESS. The partners are targeting both the newbuilding and retrofit markets.

Safety has been a top priority in battery development at Sterling PlanB, with a particular focus on thermal runaway. The company's systems meet DNV's 2020 rules for commercial vessel batteries, with close attention on preventing the spread of fire by eliminating the propagation of thermal runaway within a battery module.

Brent Parry, Sterling PlanB CEO, stressed that ESS will play an essential role in shipping's decarbonisation journey. "Regardless of vessel type, all vessels can benefit from ESS installation, helping them to save fuel, operate with a more stable load, and increasing safety with improved backup power," he said. "However, integrating battery technology into vessel design requires specific expertise, and it's important that ESS installation is considered as an integral part of a project, rather than an afterthought."

ICE Chairman and CEO, Steinar Draegebo, commented: "Sterling PlanB are proven leaders when it comes to ESS technology. We're proud to be working with a company that prioritises safety and has the technical knowledge and capability to really push the boundaries of what's possible with marine batteries. Sterling PlanB's technology will help us to meet our customers' expectations of fuel efficiency, increased safety and reduced greenhouse gas emissions."

The ESS unit
Source: Sterling PlanB

Japanese partners plan wind power for Capesize bulkers

JOINT RESEARCH | Osaka-based Namura Shipbuilding Co. Ltd. and Tokyo ship operator, NS Kaiun Kaisha Ltd., are collaborating in a joint research project aimed at using wind energy to raise efficiency on board a 183,000dwt Capesize bulk carrier. Shipbuilder Namura is convinced that future fuel-efficient technologies will incorporate wind energy as an indispensable source of power. The company has applied for a patent for its extending sail system, which is located under-deck between cargo holds and can generate extra forward thrust in favourable wind conditions.

When in use, the over-deck sails can be extended laterally to increase wind area and energy. They can also be rotated to generate the greatest benefits from wind direction. During cargo operations or when wind conditions are unfavourable, the sails are stored again below deck.

SOLAS line-of-sight requirements are a consideration for the Capesize bulker and therefore the size and height of the sails will be adjusted accordingly, the partners said. This will mean steadily tapering the height of the sails between the bridge and the bow and reducing their width in forward areas so that vision from the brigde is not obstructed.

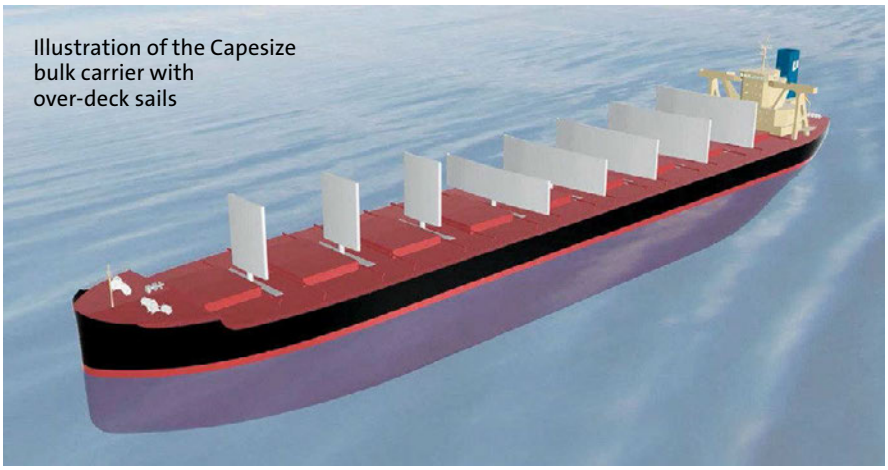

Illustration of the Capesize bulk carrier with over-deck sails
Source: Namura Shipbuilding

Combined wind-solar power systems awarded AiP

INTEGRATED RENEWABLES | ClassNK has awarded Approval in Principle (AiP) to a novel renewable energy system developed by Eco Marine Power (EMP), based in Fukuoka, Japan. The Aquarius Marine Renewable Energy with EnergySail combines renewable energy from wind and sun that is obtained by a rigid sail and a solar panel on deck.

"Aquarius Marine Renewable Energy is an advanced integrated system of rigid sails, marine-grade solar panels, energy storage modules, charging system and marine computers that enables ships to tap into renewable energy by harnessing the power provided by the wind and sun," the company said. "The array of rigid sails is automatically positioned by a computer system to best suit the prevailing weather conditions and can be lowered and stored when not in use or during bad weather," it added. "The rigid sails are based on EMP's EnergySail technology and these renewable energy devices can even be used when the ship is at anchor or in harbour."

The application from EMP was reviewed by ClassNK and its feasibility assessed in relation to the classification society's Rules for the Survey and Construction of Steel Ships; guidelines for Wind-Assisted Propulsion Systems for Ships; and Large-capacity Storage Batteries."

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Deck-mounted LNG tanks open up new retrofit market

TURNKEY PACKAGE | Owners of large tankers and bulk carriers can now consider a new retrofit opportunity, with deck-mounted LNG fuel tank systems developed by UK-based Newport Shipping. The concept, which has been awarded Approval in Principle by DNV, will enable LNG engine replacements for existing VLCCs and Capesize bulk carriers.

The deck tanks can be installed without major hull modifications, the company said, paving the way for new engines that cut emissions today and offer potential to burn carbon-neutral methane and biogas in the future. Tank capacities are based on typical trading profiles of large vessels and will provide sufficient fuel for one single voyage.

"LNG is one of the cleanest transition fuels currently available globally and can be used with minimum modifications to a ship," declared Newport's managing director, Lianghui Xia. "CO_2 emissions can be reduced by between 20% and 30% just by switching to LNG without installing any other equipment."

The near-term reduction in emissions is a "practical and cost-efficient solution," Xia said, as the development of new zero-carbon fuels such as hydrogen and ammonia continues. He pointed to added pressures from regional regulations, as well as financiers and shipping customers who are watching progress on decarbonisation closely.

LNG, which still only provides propulsion energy for a small number of vessels on the water, is gaining ground fast. According to recent figures from DNV, close to a fifth of vessels ordered in the first quarter of this year are set to have LNG engine installations. Advocates of the fuel, which many believe can help shipping's transition to new fuels in the future, point to its abundance and low cost. Bunkering infrastructure is expanding quickly, they point out.

In January, Newport Shipping launched a subsidiary, Newport Maritime Services (NMS), and a plan to offer shipowners a digital platform for repair and conversion projects. This would simplify the process of obtaining quotes and negotiating with different yards, the company explained at the time, by adopting a coordinated approach and using a selection of shipyards.

The platform shows shipyard availability and provides priority access to owners and operators and instant quotes for routine repairs. The group is also offering retrofit finance for qualifying customers, enabling owners to spread 60% of the cost of projects over periods of up to seven years.

In January, NMS revealed a network of eleven shipyards participating in its new digital platform. Since then, the company has added four more yards and negotiations are in progress with six others, a company spokesperson said.

RoPax ferry gets longer and greener

STENA SCANDICA | The RoPax vessel *Stena Scandica,* formerly *Stena Lagan*, is about to re-enter service, having completed a project at Sedef Shipbuilding in Turkey to increase cargo capacity by about 30%. The vessel was split in half to enable the addition of a new 36m-long section.

Following a celebration at the Turkish yard to mark completion of the project, the *Stena Scandica* is now at sea, bound for northern Europe, where it will resume service on the company's route between Nynäshamn and Ventspils in Latvia.

The larger vessel, with a passenger capacity of 970, now has a length of 222m and cargo space of 2,875 lane metres. Eighty new cabins have been added, taking the total to 202, and the ship's interior has been modernised, with new shops, upgraded passenger lounges and a new sundeck aft.

The project included a redesigned bow section which now enables simultaneous drive-through loading and unloading. Together with internal ramps in both directions, port calls will be significantly shorter, Stena RoRo said. Other features of the project include extra bow thruster capacity, installation of hybrid emissions scrubbers, and a new ballast water treatment system.

Stena RoRo AB's managing director, Per Westling, commented: "Extending a vessel is a cost-effective way of increasing cargo capacity, while gaining room for more passengers. The new interior design and application of modern technology entail an upgraded passenger concept, with more efficient operation and reduced emissions per cargo unit."

Air lubrication cuts fuel burn

LNG CARRIER | Tests of an air lubrication system on board the 170,000m^3 LNG carrier, *Methane Patricia Camila*, have confirmed fuel savings of 6.6%, according to clean technology company, Silverstream Technologies and vessel charterer, Shell. The retrofitted technology was tested by engineers from the two companies at various vessel speeds during the ship's normal operations.

Silverstream's air lubrication technology is based on the creation of a thin layer of microbubbles over the flat bottom of a ship. This reduces frictional resistance. The air lubrication system was installed during a routine drydocking of the 2010-built vessel undertaken in October 2020 at the Sembcorp Marine Admiralty Shipyard in Singapore. The installation was completed on budget within the drydock schedule, Silverstream said. Both design and installation were approved by ABS.

Thanking charterer Shell for its support in the project and its commitment to pioneering clean technologies, Silverstream's Founder and CEO, Noah Silberschmidt, said: "It is great to announce that retrofitting the Silverstream® System on board the *Methane Patricia Camila* has already had a significant positive impact on fuel consumption and emissions, with 6.6% savings verified during initial testing. With fuel bills only set to rise in the future, owners need to invest in fuel-agnostic technologies that are proven to save costs and emissions, without impacting the flexibility or profitability of the vessel."

A flexible sensor unit for continuous emissions monitoring

SCIPPER PROJECT Limiting excess emissions and adhering to official guidelines is critical in reducing greenhouse gas emissions in the maritime sector. Furthermore, operating costs can only be kept to a minimum if fines for exceeding emission thresholds are avoided. To collect and measure emissions data reliably, Germany's Fraunhofer CML is part of the SCIPPER project consortium, as explained by Vincent E. Schneider and Jonathan Weisheit.

To reduce emissions effectively, it is vital to know to what extent a ship emits certain pollutants. Acquiring the data normally involves cost-intensive retrofitting of complex sensor infrastructure, often directly installed into the ship's exhaust system, where sensors must withstand harsh conditions. Consequently, adhering to emission regulations is a cost-intensive and complicated process that cannot be integrated easily.

Fraunhofer CML's approach is to implement low-cost sensors which measure gaseous components in addition to particulate matter close to or, where possible, within the exhaust plume. The measurements are then integrated into a dedicated data analysis platform.

The concept goal is to offer a new and cost-effective way for shipowners, shipping companies and administrative bodies to meet current and future emission regulations. Within the SCIPPER (Shipping Contributions to Inland Pollution Push for the Enforcement of Regulations) project, Fraunhofer CML is developing an effective measurement system – the Mobile Environmental Sensor Unit (MESU II) – combined with the cloud-based Environmental Shipping Monitoring Centre (ESMC). These two tools enable emissions data to be collected and analysed, with results made available to those involved.

MESU II will be tested and compared extensively with other measurement systems. Comprehensive test campaigns are part of the SCIPPER project and are to be performed in the Baltic and Mediterranean Seas this summer.

The SCIPPER project

While one sensor system is often not capable of capturing the complete scope of a ship's emissions, let alone across a whole fleet of ships, the SCIPPER project is combining a number of sensor systems and measurement technologies, allowing for emissions monitoring of vessels under real-world conditions.

The test conditions and applied technologies have the potential and capacity to be used by enforcement authorities to oversee the compliance of ships with emission regulations and limits. These investigations are performed within regulatory enforcement scenarios to assess the impact of shipping emissions on air quality.

The core concept of the project originates from regulations implemented in recent years. Specifically, it addresses the requirements of MARPOL Annex VI, which mandates a maximum fuel sulphur content of 0.1% in sulphur emission control areas (SECAs). Since 2020, a sulphur content limit of 0.5% applies in waters outside SECAs, with even higher restrictions in European waters.

This underlines the need for cutting emissions of harmful pollutants such as sulphur oxides, as well as nitrogen oxides and particulate matter (PM), which also impact air quality, particularly in coastal areas. To enable the effective implementation of regulations and limits, SCIPPER makes possible a systematic monitoring of ships' compliance by measuring shipping emissions at various stages of normal operation.

To achieve this goal, existing technologies are combined with innovative techniques to assess if individual ships are adhering to existing SOx and future NOx and PM regulations. To push the capabilities of such a monitoring system further, techniques to characterise PM, including ultrafine particles (UFP) and black carbon (BC) are being investigated for future applications.

Scientific measurement campaigns

To achieve the ambitious goals of the SCIPPER project, the many technologies implemented include systems both on shore and at sea, as well as airborne and satellite systems which deploy in-situ, optical or remote technologies.

Five scientific measurement initiatives will focus on shipping lanes in the North and Baltic Seas, the English Channel and

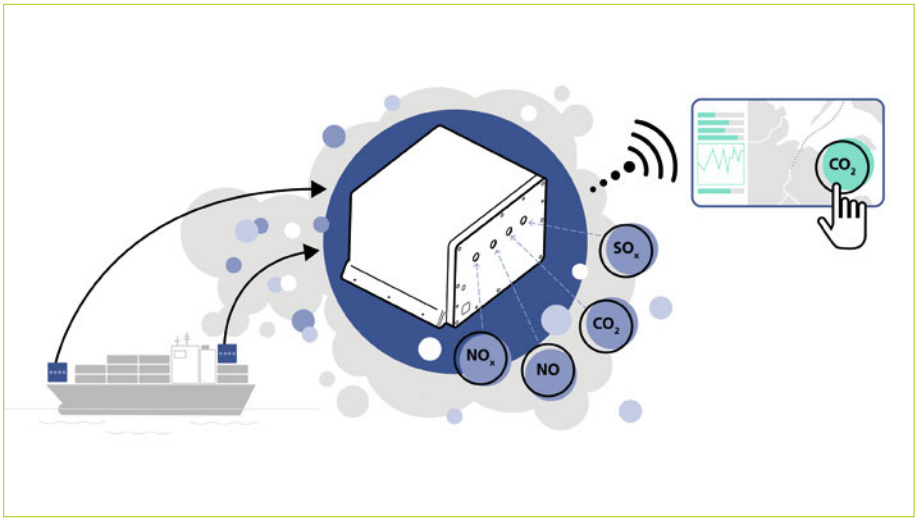


Figure 1: Concept of measurement during SCIPPER campaign C2 Source: Fraunhofer CML

the Mediterranean Sea. For Fraunhofer CML, the campaign in the North and Baltic Seas is of particular interest. The MESU II will be deployed for several weeks on the deck of a ferry in service.

Fraunhofer CML will use this valuable data to assess the quality of its measuring concept, and contribute to SCIPPER with a low-cost approach. Furthermore, it will provide all partners of SCIPPER with a database and user interface where project data will be stored, visualised, and analysed.

Design and concept

Bearing in mind these requirements and likely operation in harsh sea conditions, the challenging task of designing and manufacturing the MESU II began. The goal was to design, build and test a robust and reliable system that could be deployed for weeks in open sea conditions, capable of measuring NO, NO_2, SO_2, CO_2 and PM with high temporal resolution. Data would have to be stored locally and sent to a cloud service for direct access and immediate analysis.

The design, shown in Figure 2, and the low-cost approach demanded a manufacturing technique that allowed for repeated but inexpensive prototype iterations to verify the design within a short space of time.

The company's expertise in rapid prototyping and 3D-printing provided the ideal starting point to implement the custom-made and complex design while allowing for a space-saving installation of the electro-chemical sensors. With the basic concept tested in an earlier design, the main challenge was to achieve a high degree of sealing to withstand rain and splash water. The double layered and reinforced hull guarantees protection for the sensor probes, which are exposed to ambient air naturally, by specifically shaped outlets.

The MESU II features redundant local data storage but preferably, all data is directly sent to the Fraunhofer CML database using long-term evolution (LTE) technology. To improve overall accuracy and reduce the risk of interference from background pollution and nearby ship plumes falsifying data, two MESU II will work in tandem. One will measure in close proximity to the plume while a second unit with more sensitive sensors will be positioned at a greater distance from the ships' exhaust to capture any background concentrations. All this data is collected and sent to shore, where it is stored in a database which is then integrated directly into the ESMC.

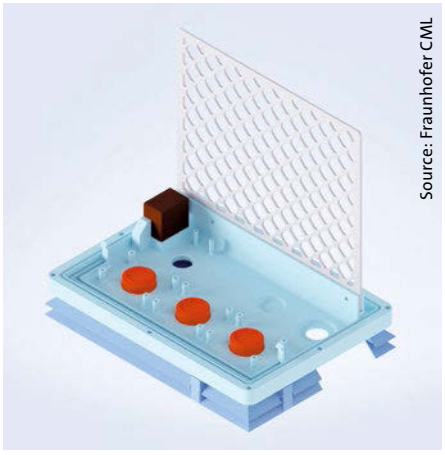
Concentrations of different emissions are displayed for every trip previously completed by a monitored ship. Furthermore, real-time data can be displayed for data transferred using the AIS standard. This allows for both live monitoring and extensive post-processing of recorded data.

GPS or AIS data enable unambiguous assignment of a ship's location to emission measurements, allowing mapping of measurements of remote technologies such as satellite observations to a specific vessel. This can be especially useful if a single ship needs to be monitored in a locally limited territory where certain emission values must not be exceeded.

Continuous development for better monitoring

Against the background of increased awareness of air pollution and greenhouse gases affecting the atmosphere permanently, Fraunhofer CML is aiming to facilitate emissions monitoring in different scenarios and a range of applications, not limited merely to maritime. One example is the company's test campaign together with the I2PANEMA project, which is working on a digitalised harbour environment.

The continuous exchange among researchers at Fraunhofer CML led to a test setup, where the robustness of the MESU II was assessed through a successful installation on a HADAG ferry in the Port of Hamburg. While continuously gathering emissions data, the functionality of the unit's sensors and their measurement accuracy were approved in cooperation with HTK Hamburg.



Source: Fraunhofer CML

Figure 2: Layout of MESU II and its main components (without the cover) showing the modular design approach for easy and fast adaptations to new or different sensors

The next iteration step has already begun: a miniature version of the MESU II is being developed, with the goal of being deployed as a drone payload, extending Fraunhofer CML's capabilities to measure emissions also from the air, which is applicable for a wide range of scenarios.

The company's know-how and resources of additive manufacturing and rapid prototyping are used to adapt the design, once optimised for a maritime environment, to the conditions found in drone applications. The low-cost and easy-to-apply approach is interesting for anybody looking for a general assessment of local emissions or monitoring of ambient air, inside and outside.

Acknowledgment
The SCIPPER project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nr.814893.

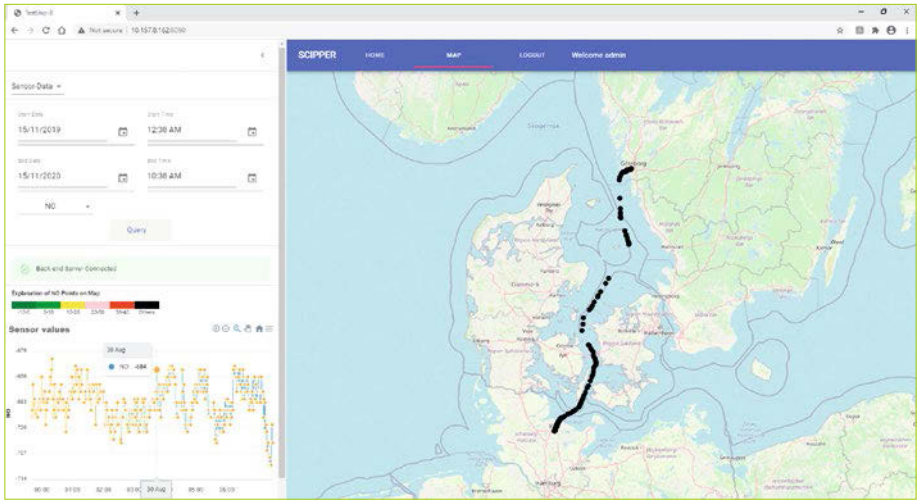


Figure 3: The SCIPPER user interface displays emission values during a ships trip (exemplary and randomised data)
Source: Fraunhofer CML

New regulations and guidelines accommodate "green" future of shipping

ULEVS | Classification society Bureau Veritas (BV) has developed a new notation to recognise the performance of ultra-low emission vessels (ULEVs), together with rules and guidelines on ammonia as marine fuel.

Jan De Nul Group's newest trailing suction hopper dredgers (TSHDs) *Sanderus*, *Ortelius*, *Tristão Da Cunha*, *Afonso De Albuquerque*, and *Diogo Cão* have become the first ships to receive BV's new ULEV notation. The Jan De Nul units are specifically designed for ultra-low emissions and have been equipped with two-stage selective catalytic reduction units and filter systems.

The vessels can outperform the most stringent low emissions regulations, BV claimed in a statement. They are currently operating on clean marine diesel fuel.

The ULEV notation can be assigned to ships that exceed existing MARPOL requirements for lowering polluting emissions that potentially endanger human health and the coastal environment. The voluntary notation accounts for stringent air quality limits, including hydrocarbons, carbon, NOx and particulate matter, as well as particle numbers. The notation is especially relevant for vessels operating frequently in highly populated coastal areas.

Laurent Leblanc, senior vice president Technical & Operations at Bureau Veritas Marine & Offshore commented: "Preserving our environment is nowadays at the heart of all innovation strategies. Thanks to Bureau Veritas expertise and our environmental commitment, we have pioneered the development of rules for low-emission vessels and today we are very proud to accompany Jan De Nul on their sustainability journey.

"BV welcomes the initiative taken by Jan De Nul to make their vessels more environmentally efficient than the requirements of applicable maritime regulation. Bureau Veritas is proud to support and work with shipowners on their sustainability journey."

Patrick Jan, Product Manager at Bureau Veritas Marine & Offshore, added: "The Bureau Veritas additional class notation ULEV is the most advanced set of requirements regarding the capacity of a ship to emit gaseous pollutants and particular pollutants at a very low level. It is certainly a significant milestone on the path to reducing maritime environmental impact."

Source: Bureau Veritas

The TSHD *Sanderus* is one of the vessels that has received BV's new ULEV notation

Beside the ULEV application, Jan De Nul Group is also testing the adoption of 100% renewable fuels made from waste flow, as a certified sustainable substitute for fossil diesel fuels. Since the end of 2019, its first trailing suction hopper dredger in Zeebrugge, *Sanderus*, has been operating on 100% biofuel. The marine engineering company is now considering a switch to biofuel for other dredging vessels in its fleet as the fuel becomes available in larger quantities.

"Adopting the Bureau Veritas additional ULEV notation and operating on biofuel is reducing the environmental footprint of shipping substantially, thus readying the industry for the future. Such a scenario is particularly suitable for marine construction vessels such as dredging or offshore wind farm installation and service vessels or ferry and harbour operations," said Rolf Stiefel, Bureau Veritas Marine chief executive for Central Europe and Russia.

Ammonia as marine fuel

With the latest Ammonia-Prepared notation and a Rule Note for ammonia as a marine fuel, BV aims to support shipowners, designers, shipyards, and charterers in advancing their journeys toward using ammonia and a zero-carbon future.

The Ammonia-Prepared notation is applicable to newbuildings and certifies that a ship has been designed and constructed as ready to be converted to use ammonia as fuel at a later date. The notation targets the spaces and structural components that will accommodate future ammonia fuel tanks, fuel handling equipment and ammonia vapour treatment installations. Ammonia-Prepared also covers specific requirements for the conversion of engines and boilers from using fuel oil, LNG or multiple fuels to ammonia.

The notation was developed in collaboration with different stakeholders including shipowners, equipment manufacturers, designers and shipyards. Ammonia-Prepared is a prelude to a full Rule Note on ammonia as fuel: NR 671. This will primarily concern the safety aspects of managing ammonia in storage tanks, fuel-piping systems, and during bunkering.

Ship&Offshore Buyer's Guide

The Buyer's Guide serves as market review and source of supply listing. Clearly arranged according to references, you find the offers of international shipbuilding and supporting industry in the following 17 columns.

1	Shipyards	Page II	10	Ship's operation systems	
2	Propulsion plants	Page II	11	Deck equipment	Page IV
3	Engine components	Page II	12	Construction + consulting	Page IV
4	Corrosion protection	Page III	13	Cargo handling technology	
5	Ship's equipment	Page III	14	Alarm + safety equipment	Page V
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1 Shipyards

1.06 Repairs + conversions

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2 Propulsion plants

2.01 Engines

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spareparts@maridis.de • www.maridis.de

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2.02 Gears

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www.rw-kupplungen.de

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2.05 Propellers

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3 Engine components

3.03 Pistons + cylinder liners

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3.10 Injection systems

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4 Corrosion protection

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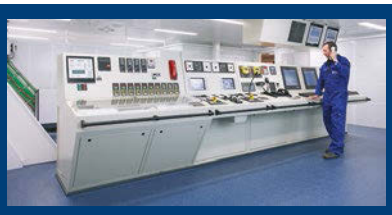

8 Measurement + control devices

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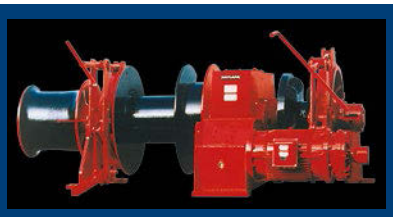

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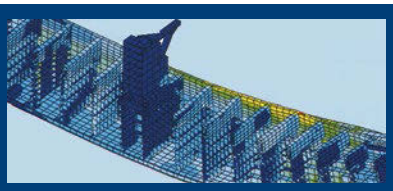

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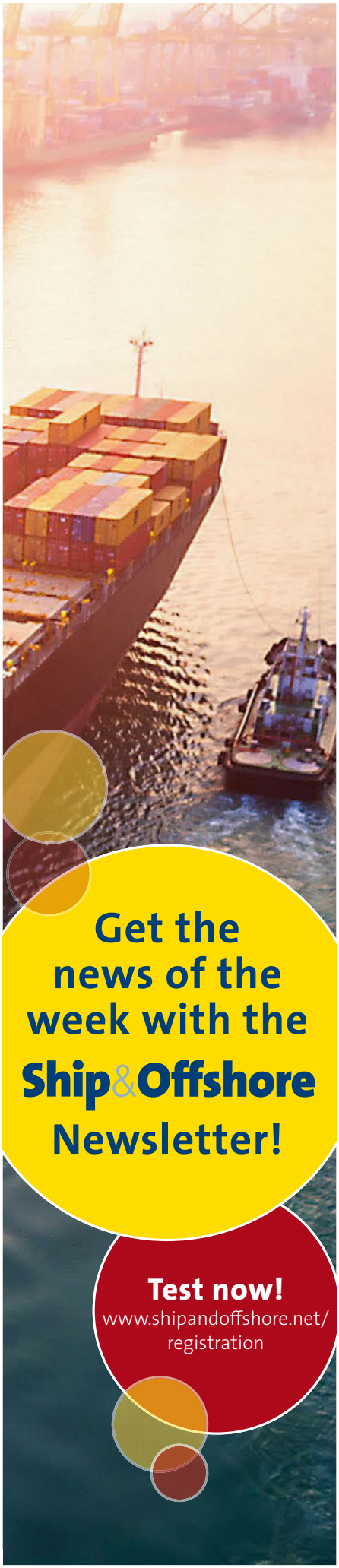

18 Buyer's Guide Information

Buyer's Guide

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Scandlines reports improved speed and power performance

PPG SIGMAGLIDE® 1290 | When ferry operator Scandlines decided to upgrade the hull coating on the 142m-long RoPax ferry *Deutschland*, the company turned to PPG Protective and Marine Coatings. Scandlines wanted to increase vessel energy efficiency by reducing power loss, use a biocide-free coating to support its green agenda, and obtain guaranteed performance.

The *Deutschland*, which serves the Rødby–Puttgarden route, was drydocked at the Remontova shipyard, Poland, in March 2020 for blasting and re-painting. The ship's hull was coated with PPG Sigmaprime 700 and then with PPG's + hull coating, PPG Sigmaglide 1290.

The latest generation PPG Sigmaglide 1290 fouling release hull coating is based on a 100% pure silicone binder system. The biocide-free product helps improve a vessel's power performance and support compliance with the Energy Efficiency Existing Ship Index (EEXI), reducing greenhouse gases and achieving efficiency requirements, PPG said. In addition to a clean hull, this coating delivers optimal performance through reduced power and minimal speed loss, the company added.

The primary difference of PPG Sigmaglide 1290 compared with copper-based antifouling coatings is its much lower frictional resistance. According to PPG, it is also characterised by its low surface energy, resulting in lower power consumption and reduced CO_2 emissions.

Drydocking in practice

For best coating performance, a vessel should be fully blasted or hydro-jetted. The former can create the appropriate surface profile whilst the latter only reveals what has been previously generated. Prior to the application of the new paint system, the dock itself has to be clean and free from any dust or debris.

Ideally, the keel blocks are cleaned and protected to remove dirt from the vessel's surface. Furthermore, the areas adjacent to the silicone application should be protected with temporary coverings to ensure no overspray is deposited on these surfaces.

A successful drydock project also requires coordination and supervision; the correct mixing and application techniques must be followed. The applicator should also be able to demonstrate experience with this type of product, otherwise training will be required.

Antifouling systems will need to be refreshed during docking intervals because of action of the anti-fouling during the in-service period. Silicones are normally washed at low pressure in drydock and spot-repaired in areas with mechanical damage.

Reducing emissions

Scandlines has converted the four ferries on the Rødby-Puttgarden route to hybrid diesel-electric propulsion in a project co-financed by the European Union. As a result, Scandlines said it was able to reduce CO_2 emissions by up to approximately 15,000 tonnes per year.

In order to verify the speed performance and the eventual CO_2 emissions reduction gained from high performance coatings, a range of agreed data is provided by the customer to calculate power consumption and speed loss over time.

This includes power consumption obtained by a torque meter on the shaft/shafts of a vessel combined with shaft revolutions. This calculates the power consumed in relation to vessel speed over a set period of time, taking different factors like draught, water depth and wind into account.

The use of a torque meter is vital to provide an accurate reading, taking into account engine maintenance and fuel consumption. Scandlines was also able to use the power consumption figures to track the exact performance of the electric motors. PPG can then compare the figures from the reference period with the remaining in-service period in order to calculate and verify the guaranteed average power saving as per ISO19030-2.

Since redelivery, the first ship has been operating on its dedicated route with excellent speed and power performance and no growth on the hull, according to diver checks. Further to these positive results, Scandlines has decided to convert the hull coatings across its fleet to PPG Sigmaglide 1290, selecting PPG as exclusive coatings provider for all drydockings and sea stores for the next four years.

Scandlines reports significant fuel savings by upgrading the coatings on its ferries

Upgrading wastewater treatment for operation in special areas

CRUISE SHIPS Stricter requirements for onboard sewage treatment plants on passenger ships now apply to the Baltic Sea, which has been declared a special area by the International Maritime Organization (IMO) in accordance with MARPOL Annex IV [1]. Arndt Kaiser, of the Development and Assessment Institute in Waste Water Technology at RWTH Aachen University, explores the possibility of upgrading onboard sewage treatment plants for nutrient elimination in cruise ship operations.

Since June 2021, only ship sewage treatment plants designed for nutrient elimination and which comply with the following limit values and elimination rates are allowed:

- Phosphorus: 1 mg/l or 80% reduction;
- Nitrogen: 20 mg/l or 70% reduction.

For newly built ships, these regulations have been in force since June 2019 with the exception of single voyages of passenger ships to Russian territorial waters east of 28°10' longitude and back, which will only apply until June 1st 2023. The option for intermediate sewage storage and discharge ashore still applies.

Ship sewage treatment plants for passenger ships could therefore offer further nutrient elimination. While phosphorus elimination is possible quite easily by installing a precipitant dosing station, it is more difficult to eliminate nitrogen.

Biological nitrogen elimination is carried out in two stages: nitrification and denitrification. During the biological process of nitrification, ammonia is converted to nitrite and then into nitrate. In the process of denitrification, nitrate is converted to nitrogen gas.

The micro-organisms involved in the two treatment steps require different environmental conditions. Nitrification processes require aerobic conditions and denitrification processes anoxic conditions, free of dissolved oxygen. Preferably, both processes take place in different reactor chambers. The standard treatment method is designated as upstream denitrification.

Passenger ship operators are now facing questions about how to deal with existing shipboard sewage treatment plants. Do existing treatment installations have to be replaced, or is it possible to upgrade the necessary treatment stages?

The NAUTEK project

The joint research project NAUTEK (Sustainable Treatment Technologies for Wastewater Treatment on Cruise Ships) aims to contribute significantly to ensuring environmentally compatible cruise shipping through technological developments. The German Federal Ministry of Economics and Energy funded the three-year project (2014-16) as part of its "Next Generation Maritime Technologies" research programme.

NAUTEK examined the current practice of waste water treatment on cruise ships. The central objective was to develop a comprehensive and innovative treatment concept for all black and grey water streams, which have been shown to be significantly more contaminated with organic pollutants and nutrients than wastewater streams from domestic sources [2].

The investigations were focused on the environmental conditions for nutrients to comply with the discharge limits for shipboard

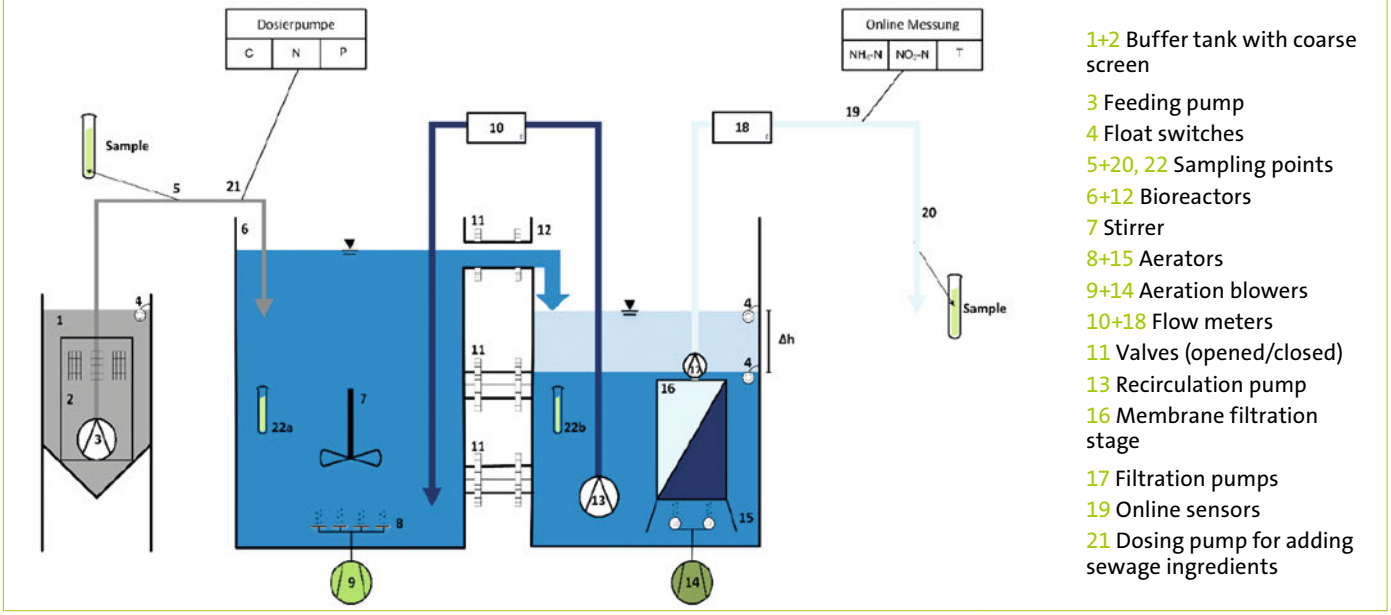

Figure 1: Membrane test plant

Source: RWTH

treated wastewater, now introduced in special areas (such as the Baltic Sea) for the first time. The objective is the development of performance- and space-optimised ship sewage treatment plant technologies for nutrient elimination based on membrane technology, taking into account the specific wastewater matrix of cruise ships.

Materials and methods

The development of the ship sewage treatment plant technology was carried out using a membrane test plant operated at the Development and Assessment Institute in Waste Water Technology at RWTH Aachen University. The test plant consisted of an upstream mechanical treatment system (Pos. 1+2), an activated sludge reactor (Pos. 6) and a membrane bioreactor (Pos. 12+16). The usable reactor volumes varied between 0.5m³ and 0.6m³ per reactor (see Figure 1).

The treatment method favoured in the investigations was the so-called 'intermittent nitrogen elimination'. In comparison with the upstream denitrification procedure, this process is based on the temporal and not necessarily spatial sequence of the treatment steps nitrification and denitrification. Therefore, the number of reactor chambers required can be reduced, making the upgrade of existing treatment plants much easier.

Considering onboard sewage treatment plants according to MEPC 227.64 [3], upstream denitrification was applied for the first time and therefore represented an innovative treatment method. Three different configurations were tested (see Figure 2). Different functions were assigned for the two reactors with the aim of adjusting the system settings in such a way that a target value of TN < 20 mg/l could be achieved in the effluent. Phosphorus elimination was not part of the investigation.

The test plant was fed with domestic wastewater. To customise the wastewater matrix and to make it comparable to the one on cruise ships, ethanol and urea solutions were added to increase the influent loads of organic pollutants and nitrogen.

The average COD concentration was 1,500 mg/l, the average nitrogen concentration was 150 mg/l.

Results

For each test configuration, nitrogen elimination rates of more than 95% and corresponding effluent concentrations of less than 4 mg/l were achieved. The average nitrogen elimination levels during the test phases varied between 63% and 80%.

It was possible to combine the different treatment steps of nitrogen elimination and membrane filtration in one reactor and to control them via time schedules. There was no need to use different reactor chambers for nitrification and denitrification.

Even the oxygen-rich air introduced during membrane filtration did not lead to any disturbance of the denitrification process taking place in the same reactor, as the present wastewater matrix makes the denitrification process play a minor role.

Detailed information on the investigations, test procedures and test results are presented by Dorgeloh et al [4].

Upgrade or replace

The investigation found that the specific onboard wastewater matrix of cruise ships allows for a high degree of flexibility considering the various different methods and configurations of treatment steps. In some cases, existing sewage treatment plants can be upgraded rather than replaced, leading to significant cost savings.

For the approval of upgraded sewage treatment plants, clarification of applicable laws is important. It can be assumed that

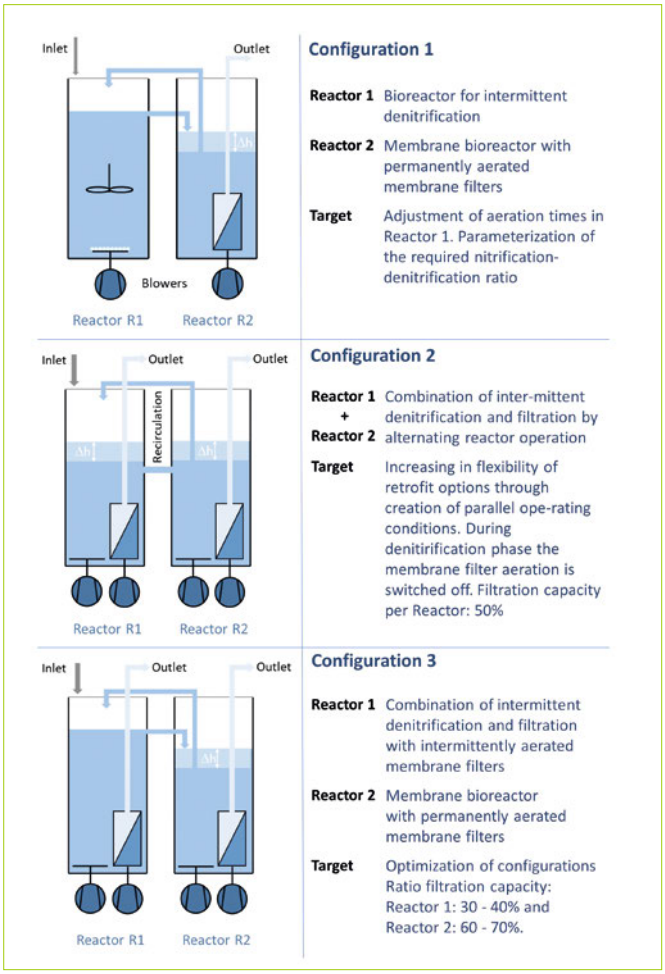

Figure 2: Test configurations

an approval can be granted by a performance test carried out in accordance with valid approval principles. Information on this can be provided by accredited test facilities such as the Marine Testing Department at the PIA Institute.

The research project demonstrated the need to question the existing approval test procedure, especially referring to sewage treatment plants with nutrient elimination. The requirements, some of which were set out in the 1970s, are out-of-date and do not meet sustainable environmental protection requirements. In particular, there are no parameters governing the composition of wastewater used during the test, which has a significant influence on the selected treatment method. In future, the required wastewater matrix should be adapted to each specific situation.

A successful test of a treatment plant on land is no guarantee of a stable operation at sea, whereas a test on board could provide certainty about suitability and efficiency.

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[3] MEPC.227(64), Resolution MEPC.227 (64). Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants, adopted on 5 October 2012 – https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.227(64).pdf
Last status of the query: May 2021
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Regulating grey water – a necessity

TREATMENT PLANTS The IMO's MARPOL Annex IV is being revised to confirm the lifetime performance of sewage treatment plants (STPs). This may finally endorse grey water regulation – a necessity that is long overdue, says a conglomerate of scientists, shipowners and suppliers.

A ship's sewage (black water) is collected from toilets, urinals and hospitals. The IMO's MARPOL Annex IV prohibits its discharge, except when treated by a sewage treatment plant (STP) or discharged more than 12 nautical miles from the nearest land. A ship's grey water, collected from showers, wash basins, laundries, and galleys, is not regulated.

Grey water has more pollutants, measured as biochemical oxygen demand or chemical oxygen demand, and hence greater environmental impact than black water (Table 1) [1-4]. But logical attempts to regulate grey water have been to no avail [5].

It has been widely acknowledged that the vast majority of approved STPs are discharging 'virtually untreated sewage' [6], and the regulations need to be made effective. What may not yet have been recognised is that, for good technical reasons, an effective black water regulation may not be readily achieved without regulating grey water.

Most concentrated sewage vs most stringent standard

For decades, marine regulators have assumed that a ship's sewage is similar to sewage on land. They cannot be more wrong. A ship's sewage is far more concentrated, since urban wastewater contains groundwater infiltration, rainwater, and grey water. Onboard vacuum collection systems push the concentrations even higher, making ship sewage the most concentrated across all industries (Table 2) [1]. Yet, ship sewage is subject to more stringent faecal coliform limits when compared with the discharge standards around the world, including the EU land-based rules (Table 3).

It is more so when it comes to the challenging nutrient standards. Under the Baltic Sea Action Plan [7], local communities of up to 300 population equivalent (p.e.) are not required to remove total phosphorus (TP). Conventional biological wastewater treatment plant on land can achieve the total nitrogen (TN) target of 35 mg/l or 30% without introducing nitrogen removal technologies. As such, local communities of up to 10,000 p.e. are not required to remove TN (Table 4).

This is not because the land-based industries are not ambitious, or that local communities do not care. It is quite the opposite. They have evidence-based, practicable, and sustainable environmental regulations that are enforced by performance monitoring, aimed at protecting the environment, using best available technologies without entailing excess costs or adverse environmental impact. In contrast, passenger ships carrying as few as twelve passengers are given nutrient standards that are considered unnecessary, with no benefit, and unviable for land-based industries (Table 4).

A ship's black water can have nutrient concentrations ten times that of urban wastewater (Table 5). There are other challenges. Ship operators can never be as familiarised with, or dedicated to, an STP as full-time operators in treatment plants. Ships have far less space, far poorer access, and have real challenges in logistics and services. Plus, ships pitch and roll.

Nobody complained. The IMO's type approval regime has made impossible tasks so 'easy'. Shipowners who won't trust a Bunker Delivery Note have embraced the certification of environmental technologies. Even those ships not applicable for nutrient removal have joined in, oblivious of the implications. It may not be a surprise that the first historical and courageous withdrawal of a certification under the MARPOL Convention was to an STP type-approved for nutrient removal [8].

Conditioning vs dilution

The assumption of ships' black water being similar to urban wastewater is evidently wrong and therefore the assumption that a ship's black water can be readily processed to meet the most stringent standards is not evidence-based. It is logical and essential to bring concentrations of black water closer to that of urban wastewater by 'conditioning'.

After all, most STPs are tested using urban wastewater that already contains grey water. Large STPs tested on board cruise ships include grey water [9,10]. Under Alaska's permitting regime for cruise ships, grey water is regulated together with black water [11].

Without conditioning, the treated black water, by meeting only the percentage removal target, can still be too concentrated to be allowed into many territorial waters under national rules. Untreated black water can be too concentrated to be legally received by even the public sewer of port reception facilities. Dilution, on the other hand, takes a big step in the wrong direction by using excess amounts of sea water to dilute pollutants, thus cheating the discharge standard.

	CRUISE	CARGO
Persons on board (POB)	3,300	25
Grey water (m³/day)	1,000	2.75
Black water (vacuum) (m³/day)	80	0.63
Grey water (m³/day)	600	2.75
Black water BOD (kg/day)	280	2.2
POB : population equivalent	4	3

Table 1

	URBAN WASTEWATER	SHIP (VACUUM)	SHIP (GRAVITY)
COD (mg/l)	300-800	800-10,000	200-2,000
BOD (mg/l)	200-400	400-5,000	50-1,000

Table 2

	MEPC.227(64), >15 PERSONS	EU UWWTD, 2,000-10,000 P.E.
BOD (mg/l)	25 Qi/Qe	25 or 70-90%
COD (mg/l)	125 Qi/Qe	125 or 75%
TSS (mg/l)	35 Qi/Qe	60 or 70%
F. Coli (/100ml)	100	N/A

Table 3

	POPULATION EQUIVALENT	MEPC.227(64) >12 PASSENGERS	BALTIC SEA ACTION PLAN
TN (mg/l)	300-10,000	20 Qi/Qe or 70%	35 or 30%
	<300	20 Qi/Qe or 70%	N/A
TP (mg/l)	2,000-10,000	1 Qi/Qe or 80%	1 or 80%
	300-2,000	1 Qi/Qe or 80%	2 or 70%
	<300	1 Qi/Qe or 80%	N/A

Table 4

	URBAN WASTEWATER	CRUISE SHIP BLACK WATER
TN (mg/l)	30-60	500-1,000
TP (mg/l)	5-10	50-100

Table 5

Regulating grey water is a necessity

Regulating grey water together with black water makes the existing performance standard more attainable and practicable. Because grey water is often mixed with black water during storage and transfer on board, regulating grey water is essential for effective implementation of the proposed sewage record books.

There are other reasons too. For years, non-conformities relating to grey water have been persistent. Sending grey water to an STP's final stage is a non-conformity wrongly approved and promoted by classification societies since 2016 [12]. On occasions, ships' grey water systems are also becoming a dumping ground for regulated wastes, such as food waste and food waste derivatives, violating international marine rules and national biosecurity rules [13]. The interferences of grey water to the Ballast Water Convention also remain outstanding [14].

Regulating grey water can ultimately align the maritime industry to the rest of society in protecting coastal waters with integrated and consistent regulations, both on land and at sea.

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The Port of Rotterdam aims to optimise its port logistics
Source: Port of Rotterdam

European alliance awarded almost EUR 25 million for smart port research

FUNDING | A European alliance, headed by the Port of Rotterdam, is to receive almost EUR 25 million in EU funding to develop projects in the field of sustainable and smart port logistics. The aim is to develop a "grand plan" that can provide a framework for transport to, from, and within ports to be made carbon-free by 2050.

The research project is called MAGPIE, which is short for sMArt Green Ports as Integrated Efficient multimodal hubs. Other port partners are DeltaPort (Germany), Le Havre, Rouen and Paris (Haropa, France), and Sines in Portugal. Other participants include ten research institutions and more than 30 companies in Denmark, France, Germany, Portugal and the Netherlands.

As the largest industrial partner in MAGPIE, Wärtsilä is to receive a large slice of the grant for development of an autonomous, zero-emission e-barge for deployment in the Port of Rotterdam to ease traffic flow along the supply chain. The initiative will "demonstrate a commercially viable autonomous intra-port inter-terminal container shuttle to address an emergency capacity bottleneck for internal container transportation," the company said.

By way of explanation, Wärtsilä Voyage's Business Development Engineer, Hendrik Busshoff, added: "We believe that overland transport modes will not be able to absorb the emerging capacity bottleneck for internal container movement. So we will be delivering an autonomous e-barge concept that can greatly enhance efficiency in the Port of Rotterdam through automated seaborne cargo transshipment. Our ambition is to see these container shuttles introduced into a smart logistics network within the next few years."

The autonomous, zero-emission barge will be operated and controlled by several of the company's digital systems including the Wärtsilä SmartMove Suite. This provides a unique pairing of sensor technology with navigation systems for safe, automated ship movements. The company said that its autonomous setup has already been successfully tried and tested in congested waters, both in busy inland waterways and in international ports such as Singapore.

Meanwhile, to achieve zero-emission operation, Wärtsilä will use its electric drive train and interchangeable battery containers that can be charged with renewable power. These replaceable battery containers are known as ZESPacks (Zero Emission Services), the company said, revealing that an open access network of charging points will enable spent battery containers to be replaced with fully charged ones, thereby minimising waiting time.

The first of these battery containers is due to be installed in the weeks ahead. And they have already caught the attention of brewing company, Heineken, which plans to use them as a carbon-neutral way of supplying 45,000 containers of beer to the Port of Rotterdam each year.

Wärtsilä Voyage president, Sean Fernback, summarised how his company plans to assist in achieving some of the MAGPIE project aims. "The world's largest economies have high hopes of resolving some of their greenhouse gas challenges and their infrastructure bottlenecks with smart shipping," he said. "Since 2015 and combined with an effort to reduce ground transportation, the EU has targeted a 25% increase in cargo transportation by short sea shipping before 2030.

"We feel we can enable this. Utilising new technology, we will change short sea and inland shipping into a safer, cleaner, and more efficient link in the logistic chain, with greater accessibility to those who need it. That's why we are automating operations."

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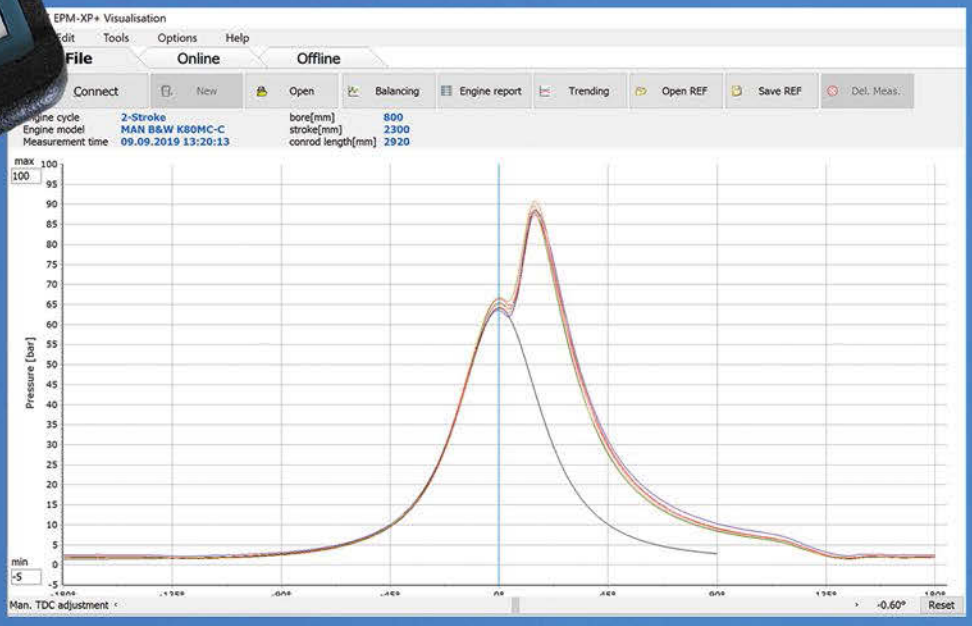

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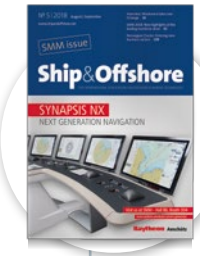

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